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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

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NOTES.

The Electric Light for Warships.—H.M.S. "Boadicea" is to be fitted at Portsmouth with the electric light.

The Antwerp Exhibition.—The exhibitors at this Exhibition propose to entertain the Executive at a banquet on the 29th instant.

Epstein Accumulators. — The current number of *La Lumière Electrique* contains an account of the construction of these accumulators.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 6th inst. amounted to £3,047.

The West Coast of America Telegraph Company.—The gross earnings of this company for the month ending October 31st were £3,475.

The Telephone in Germany.—In Berlin and its suburbs the number of subscribers to the telephone already exceeds 7,000, and is continually on the increase.

An Opportunity.—At the last ordinary meeting of the Mansfield Woodhouse Local Board Mr. Marlow gave notice of motion that it was desirable to let the public lighting by tender.

Personal.—Mr. H. Goodwin, having recovered from his illness, contracted in India, has been appointed manager and electrician of the Oriental Telephone Company's system at Mauritius.

Earthquakes.—Two severe shocks of earthquake, passing from west to east, were felt on the Lis Island, in the parish of Sorunda, Sweden, on the 9th ultimo between the hours of 9 and 10 a.m.

"The Encyclopædia Britannica."—The last volume of this encyclopædia has, in the section devoted to physiology, a quantity of interesting matter upon the electrical condition of the human body.

The Telegraph in Japan.—According to recent statistics, Japan possessed in 1881 4,000 miles of telegraphs, with a total of 10,000 miles of wire. A special modification of the Morse code, having forty-seven signals, is used.

The Royal Society. — Considerations of health have induced Prof. Huxley to place in the hands of the council of the Royal Society his resignation of the office of president, and the resignation has been accepted. His successor is Prof. Stokes.

The Telegraph in Italy.—The province of Sienne, in Italy, possesses 11 telegraph offices belonging to the Government, and 13 offices under the control of the various railways. The number of messages transmitted amounts to about 900,000 per annum.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended 6th November, were £2,366, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

The French in Annam and Tonquin.—It is said that all telegraphic communication between Annam and Saïgon is suppressed by the military authorities. General Prudhomme has forbidden the sending even of private telegrams unless they have his personal *visa*.

Fireman's Electric Lamp.—A portable incandescent lamp, fed by a bichromate battery, and intended for the use of firemen, has been introduced by Messrs. Merryweather. Except as regards its outer casing the lamp does not differ from those with which we are already familiar.

The Electric Light and the Lord Mayor's Show.—The four Pilsen lamps used on the occasion of the late civic show to illuminate the historical erection in Aldersgate were supplied by Messrs. Paterson and Cooper, and run from a Phœnix dynamo at their works in Little Britain.

City and Guilds of London Institute.—Alderman Sir R. N. Fowler, Bart., M.P., has consented to present the Institute's scholarships, prizes, and certificates at a meeting to be held on Wednesday evening, 9th December, at the Salters' Hall, St. Swithin's-lane, E.C. The Right Hon. the Lord Mayor will preside.

The Pilsen-Joel and General Electric Light Company.—Notice is given that the fourth ordinary general meeting of the shareholders of this company will be held at the Cannon-street Hotel, Cannon-street, in the City of London, on Thursday, the 19th November, at two o'clock in the afternoon.

The Lighting of the Budapest Exhibition.—The lighting of this Exhibition has, with the exception of a few Egger lamps, been entirely carried out by Ganz and Co., of Budapest. The installation includes about 116 arc and 1,200 incandescent lamps, and about ten slow-speed dynamos, driven, principally, by a 70 horse-power steam engine.

The Alternative Route to the Cape.—We are in a position to state that, practically speaking, all arrangements have been made for laying and maintaining a line of submarine cables along the West African coast, giving us not only telegraphic communication with our West African Colonies, but the much-agitated-for alternative route to the Cape.

The Telegraph in the Far East.—It is reported that the telegraph line is constructed to the Kala Abdullah, and

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is working. During Sir Donald Stewart's late stay there, sufficient material was stored at Quetta to carry the line to Herat if necessary. This department is well directed and efficient, keeping abreast of possible requirements in India.

Colonial and Indian Exhibition.—H.R.H. the Prince of Wales has appointed Sir Frederick Abel, Sir Francis Bolton, and Mr. Preece a Committee of Advice to deal with the important question of the electric illumination of the grounds and buildings next year. Mr. Cundall has also been appointed by H.R.H. as engineer in charge of the machinery and plant.

Accidents in Mines Commission.—Meetings of this commission were held on Tuesday and Wednesday at its offices, 2, Victoria-street, Westminster. There were present the chairman, Mr. Warrington W. Smyth, Sir Frederick Abel, C.B.; Mr. Thomas Burt, M.P.; Professor Clifton, Mr. W. Thomas Lewis, Professor Tyndall, and the secretary, Mr. Arthur J. Williams.

Fond of Experiments!—In the Westminster Police-court recently, William Marriott, sixteen, a chemist's assistant, was charged on remand with stealing an electric "motor," value 30s., the property of the Electric Apparatus Company, at the Inventions Exhibition.—The prisoner's mother said he was passionately fond of experiments in electricity.—Mr. Sheil, in the result, took the mother's bail for prisoner to come up if called upon and allowed him to go, with a strong caution as to the future.

The Telephone in Canada.—A new telephone system is about to be inaugurated in Ottawa, in which many great improvements are introduced. The combined result of these changes is that speech with good articulation can be modulated and distinctly heard at any distance within twenty and even thirty feet from the ear, thus avoiding all danger or annoyance, and at the same time liberating the hand from the fatigue of holding a telephone. It is intended to establish a manufactory in Ottawa.

New Room at the British Museum.—At the British Museum a new and commodious reading room has been opened for the use of persons who wish to consult the files of the daily and weekly papers. It is in the new wing at the east end of the Museum, facing Montagu-street, is fitted with larger and broader tables than those in the circular reading room, and is well lighted and ventilated. The furnishing and decoration of the room are nearly completed, and it will be eventually lighted with the electric light.

Electrolysis of Salts.—In a paper recently read before the Academie des Sciences, M. Renard stated that in solutions sufficiently dilute the amount of metal precipitated is proportional to the concentration of the liquid. The proportions of metal deposited are in the same relation as their atomic weights. According to the law of Faraday the quantity of metal precipitated being proportional to the intensity of the current, the conductivity of solutions containing equivalent atomic weights of metal is the same; as M. Bouty has sufficiently demonstrated.

The South of England Telephone Company.—We are pleased to see that Mr. Grahame, who displayed a considerable degree of energy in getting together a *clientèle* for the Northampton exchange of this company, has, in little more than two months, succeeded in doubling the original list of subscribers. We understand that it is proposed to connect Northampton with the smaller towns of Wellingborough, Kettering, and Rushden; a scheme which, if carried into effect, will greatly increase the importance of Northampton as a telephonic centre.

Telephone Litigation in America.—The New York correspondent of the *Standard* says that the Department of the Interior is now considering an application to annul Bell's telephone patent. Prof. Gray has made an affidavit in which he asserts that he filed a caveat and deposited a working model the same day that Bell filed his application for a multiplex telegraph; that Gray's caveat was treacherously taken to Bell's counsel, who revised Bell's papers so as to include the telephone, thus wholly changing the character of Bell's claim, and substantially embodying Gray's invention.

Direct Communication with Spain Restored.—The Direct Spanish Telegraph Company notify the repair of their direct cable route to Spain *viâ* Bilbao. This has been a most remarkable piece of work on the part of the new ship "Electra," and reflects very great credit indeed upon Captain Pattison and every one concerned. The cable was picked up in 2,200 fathoms, and put through in less than three working days. We doubt whether as smart a performance is on record, although the ss. "Chiltern," if we remember rightly, approached it a few years ago in the Bay of Biscay. The depth in that case was, we think, 2,000 fathoms.

The National Telephone Company.—From this company's October list of subscribers we notice that in the Aberdeen district there are now 510 instruments in operation, the number of exchange connections, including switch lines, being 455. In addition to these there are 29 private lines, making a total of nearly 265 miles of wire. The longest line is that to the Culter Paper Mills, which measures 8 miles 447 yards, and the longest private line is from Ellon to Newburgh, a distance of 5 miles 870 yards. In other districts the company have much more extensive lines in operation, notably, between Glasgow and Edinburgh, and Glasgow and Greenock.

The Life of Incandescent Lamps.—Some of the Edison and Swan incandescent lamps, placed two and a half years ago on the Great Eastern Railway Company's steamer, "Norwich," running between Harwich and Antwerp, are still living. Though only guaranteed for 1,000 hours, they have lasted close upon 7,500 hours, for their light is on about fifty-six hours a week, and the steamer has only been fourteen days off the station. Although most have been replaced, so as to avoid the chance of their suddenly going out, two of the original lamps are retained in the saloon by way of curiosity, and their light is only a trifle less brilliant than that of the others.

The Manchester Art Gallery.—At a recent meeting of the Manchester City Council Mr. Alderman Hopkinson said the Council would be pleased to learn that the receipts for admission to the present autumn exhibition at the City Art Gallery were considerably in excess of those of any former year, whilst the sales were even more satisfactory. The preparations for lighting the gallery by means of electricity were very nearly completed, and he hoped to be able in a few days to invite the members of the Council to go and see the effect of it. Meanwhile, the gallery could not be lighted in the evening, on account of the objection which owners of pictures raised to gas.

Applications of the Telephone.—A recent interesting exhibition of apparatus in Paris, by Dr. Boudet, included a modification of the telephone adapting the instrument to a variety of medical uses. In one form the pulsations of blood vessels and all sorts of internal operations were very strikingly made audible, the observer being able to hear at will the movements in any part of the body. Another telephonic appliance detected the presence of stones in the bladder, and even made

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known their character when present. Dr. Boudet also employs the telephone as a measuring instrument for accurately estimating the nervous and muscular excitement in the different phases of a disease.

Manufacture of Bichromate of Potash.—An improved method of manufacturing bichromate of potash has been devised by Mr. Rœmer, of Elberfeld. A concentrated solution of sodium bichromate is dissolved in boiling water and potassium chloride added. This mixture is then maintained at the boiling point until a mutual decomposition takes place, potassium bichromate and sodium chloride being formed. The mother liquor is concentrated, so that sodium chloride is salted out, which is removed and washed with hot water, and instead of bichromate the neutral chromate of sodium may be employed, in which case the solution is first sufficiently acidulated with hydrochloric acid to be transformed into bichromate; when the latter is treated as before mentioned.

A Story about Morse.—Florence, the actor, tells this story:—"I can remember," he said, "years and years ago, going to a dinner, given to Morse. He was an elegant old gentleman, but awfully long-winded. I had a friend with me. We listened to Morse, while he predicted great things for electricity. I remember he predicted, too, that some day men would be able to talk over the wires for distances of fifty miles, and that every ship that left harbour for an ocean voyage would be connected with the land by wires. When he got that far my friend said, 'What rot!' and we went out. I have often remembered how foolish his talk sounded to me. Yet it has been all realised, except as regards ships at sea. I believe even that will come about some day."

An Important Modification.—Mr. C. M. Gavill has presented to the Physical Society, in the name of Mr. Guerin, a cell whose liquids have been rendered immovable, and which is as a consequence portable. This result has been obtained by substituting for water a solution of agar-agar, an alga that comes from the far East. The liquid upon cooling becomes a solid and elastic jelly. The proportion of agar-agar may vary from one to five per cent., and depends upon the substances that are to be mixed with liquid. The model that Mr. Guerin has studied is the agglomerate Leclanché. Its electromotive force is slightly less (0·03 to 0·04 volt) than that of the ordinary styles of the pile. The resistance of one of these elements of medium dimensions is about 0·9 ohm. The same process may be applied to any other primary cell.

The Humming of the Wires.—Mr. M'Bride, of Indiana, has come to the conclusion that the humming of telegraph and telephone wires is not caused by the wind. He has devoted a great deal of time and attention to the matter, and has found that the sound is more appreciable on a clear, calm evening than at any other time. He is also convinced that the effect is not due to electricity, for he could detect no signs of that agent when the humming was in full force, while at times when the wire was evidently carrying current there was no sound. Mr. M'Bride considers the question a subject of investigation which may lead to important discoveries. We consider that Mr. M'Bride is mistaken in both his deductions and his conclusion. The humming is set up by vibration, which may be due to a number of simple causes, and transmitted from one point to another, even at a considerable distance.

A Visit to the Consolidated.—We learn that Mr. Todd, the Postmaster-General of South Australia, and Mr. Cracknell, Superintendent of Telegraphs for New South Wales, last week visited the factory of the Consolidated Telephone Construction and Maintenance Company, and expressed themselves highly pleased with what they saw there. The visitors were accompanied round the works by the chairman of the company and Mr. George A. Mason, the manager. The machinery lately introduced from America attracted considerable attention, as did the process of making magnets. The switchboards of the consolidated pattern got their full meed of praise, and the latest improvement, the new magnet bell with tooth-wheel gear and patent cut-out, met with approval. The Consolidated transmitter was also examined. The company claim that this instrument is the best transmitter of the human voice at present known.

Absolutely the Latest Motor.—The following curious circular has recently been issued; our readers will be able to form their own opinions of it. We are not interested in steam engines generally, but we have friends who think much of them. For their sakes, therefore, we are rather glad than otherwise that the inventor of the wonderful machine below mentioned is impecunious. Were it not so, it is dreadful to think what a revolution in science might be brought about by this gentleman's motor:—"A friend has arrived with a very valuable invention. It is a machine which works and has the power of a steam engine, without fuel or element; it can be used for tramways, mining purposes, factories, railways, and ships. The machine requires only one man for stopping or setting it in motion. One of the largest will only require two men for attention. *The machine is not subject to breakage*, therefore a great saving *on coals* and labour can be effected. To build such a machine will not cost more than a steam engine of its same power. The inventor wants to sell the invention, or to treat with gentlemen with the view of getting same patented in the whole world. *His capital is limited.*" "His capital is limited;" pathetic, but reassuring. The italics are our own.

Electro-Technics in Germany.—The following synopsis of courses in electro-technics at the various high schools in Germany is calculated to impress one with a colossal respect for minds which with so little tuition can grasp the technical and the abstruse. Berlin:—Electro-technics, four lessons; telegraphy, four lessons; practice in the electrical laboratory, six lessons; electric lighting and its various methods (special course for engineers), two lessons. Brunswick:—Electro-technics (theoretic and practical), four lessons; practice in laboratory, two lessons; other subjects, seven lessons. Darmstadt:—Electro-technics, two lessons; electrical machines, two lessons; electric lighting, two lessons; telegraphy and telephony, two lessons; submarine telegraphy, one lesson; practical exercises, six lessons; theory of potential, two lessons; application of electricity to railway work, two lessons; electro-dynamics, including induction, two lessons; practical telegraphy, one lesson, &c. At the end of the scholastic year the students are required to pass the examinations and receive certificates of competency. The subjects remaining about the same, Dresden offers a total course of seven lessons; Hanover, thirteen; Carlsruhe, five; Munich, eighteen; and Stuttgart, six. Cheerful prospect!

Society of Arts.—The hundred and thirty-second session of the Society of Arts will commence on Wednesday, the 18th inst., when the opening address will be delivered by Sir Frederick Abel, C.B., D.C.L., LL.D., F.R.S., chairman of the council. The following are amongst the papers announced: Prof. Silvanus P. Thompson, "Apparatus for the Automatic Extinction of Fires." Prof. Francis Elgar, LL.D., F.R.S.E., M.Inst.C.E., "The Load Line of Ships." F. Edward Hulme, F.L.S., F.S.A., "Technical Art Teaching." Dr. C. Meymott Tidy, "The Treatment of Sewage." C. V.

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Boys, "Calculating Machines." George Clulow, "The History and Manufacture of Playing Cards." W. H. Preece, F.R.S., "Domestic Electric Lighting." Prof. R. Meldola, F.C.S., "The Scientific Development of the Coal Tar Industry." Six courses of Cantor Lectures have been arranged—"The Microscope," by John Mayall, jun.; "Friction," by Prof. H. S. Hele Shaw; "Science Teaching," by Prof. F. Guthrie, F.R.S.; "Petroleum and its Products," by Boverton Redwood, F.C.S.; "The Arts of Tapestry Making and Embroidery," by Alan S. Cole; "Animal Mechanics," by B. W. Richardson, M.A., M.D., F.R.S. The subject of the Juvenile Lectures this year will be on "Waves," and the lecturer, Prof. Silvanus P. Thompson, D.Sc. Dates and further particulars will be announced in the Society of Arts *Journal*.

The Electric Light and the Hastings Town Council.—At the last usual monthly meeting of this Council, the annexed recommendation in regard to the electric light was read:—"The committee recommend that the existing contract with the Electric Light Company, for the lighting of the front, from the Queen's Hotel to Warrior-square, by means of fifteen 2,000 nominal candle-power arc lamps, for the sum of £450 per annum, which expires on the 26th inst., be renewed for another year."—Mr. Alderman Davis had great pleasure in moving the adoption of the report. He was disappointed at not being able to move a report embodying a more extended use of the light. It was very well known that the Electric Light Company had been in considerable difficulties during the last year or two, and had not yet felt themselves able to go in for a more extensive application of the light to the town. He hoped in another year to find that the company were in a position to extend the operation of the light, not necessarily along the parades east and west, but in the inland parts of the borough. They really could not now do without their beautiful light on the front.—Mr. Duke seconded with a great deal of pleasure. The expense was a great deal, it was true, but it was patent to everyone that the light was a most essential and admirable arrangement. It was a great pity that at present the committee were unable to extend the area of the lighting; but whilst they could have the light along the front he thought they should endeavour to continue the expense of it. They must keep pace with other towns in this matter. The report was then adopted, without opposition.

American Items.—A novel application of the electric light is to be seen in Philadelphia, where miniature incandescent lamps of 1 candle-power are used, among other things, for illuminating clock dials at night. One of the things for which Bellows Falls (Mass.) people are largely indebted to the extensive paper manufacturers of the locality is the electric light, which is furnished to the village merchants and others for a small sum. The Fall Mountain Company furnishes the power for no less than 800 electric lights, 400 or 500 of which are used in the company's different mills, and the balance by the village storekeepers and others, who are charged but 1 cent. an hour for the use of each light, which is of 16 candle-power. These lights give such general satisfaction that it seems quite likely that within a few months the plant will be so extended as to furnish many of the village dwellings with a light which it is claimed by those now using it is cheaper even than kerosene. Salina, Kan., has granted the franchise to the Salina Electric Light Company to furnish the city with Edison incandescent light, the works to be in operation by June 1, 1886.—The chimney at the waterworks pumping station at Fall River, R. I., which was struck by lightning several weeks ago, has resisted all efforts to pull it down. October 23, a company of the 1st Regiment stationed a 12-pound gun 200 feet distant and with one solid shot and thirteen unloaded shells knocked down the 40ft. of chimney forming the dangerous portion.—The Jarvis Engineering Company, of Boston, have received the contract to furnish the steam plant for the new Edison Lighting Company, of New Bedford, Mass. They will put in two Armington and Sims engines, two 6 by 16 steel tubular boilers set with the Jarvis furnace, national feed-water heater, Davidson steam pump, Korting injector, &c.

The Electric Light and Stage Effect.—At many theatres, both in London and the provinces, the electric light has been successfully used as an accessory to stage effect. It is not long since we described the very interesting and ingenious installation of arc lamps at Her Majesty's, and we have now to offer our congratulations to Mr. Edgar Bruce, of the Prince's, upon the manner in which he has availed himself of the facilities offered by the incandescent light. Thanks to this gentle illuminant, the theatre over which Mr. Bruce so ably presides is one of the pleasantest in London. Its auditorium is cool, excellently lit, and entirely free from the oppressive odour which results from the combustion of gas. Not only is the installation carried to every part of the building, but great care, attention, and taste have evidently been bestowed upon its arrangement. On the stalls level are the refreshment kiosk and smoking fernery, in which latter the incandescent lamps, half hidden amongst foliage or peeping out from curious little recesses, are most artistically grouped. In the kiosk there are but 12 lamps, in pairs; and in the fernery six only, but on the occasion of our visit they were working up to their full power and gave ample light. Theatrical criticism being somewhat out of our province, we must refrain from a commentary upon the merits of the "Great Pink Pearl" other than to say that it is very, very funny. In the last act, however, a fine effect is introduced by the instantaneous illumination of the interior of the Russian Embassy in Paris by incandescent lamps. An ordinary switch placed near the doorway, and actuated by an attendant in obedience to a simple request for "lights," transforms the stage from almost total darkness to a sudden blaze of light, and produces a powerful impression upon the audience. The whole of the lamps are run from accumulators. The installation, as many of our readers will remember, was put down by Messrs. Strode and Co., who are also to be credited with the last-mentioned arrangement.

An Important Experiment.—Within the area of the torpedo field situated opposite the sea fronts of Forts Monckton and Gilkicker, near Portsmouth, an important experiment in submarine mining has recently been carried out. At each corner of a quadrilateral was sunk a heavy mine, consisting of 500lb. of guncotton, enclosed in wrought-iron cylinders, all four being in separate electrical connection with a battery in Fort Gilkicker. Both within and without the lines, and at various known distances from the charged mines, were submerged a great number of cases of various construction and shape loaded down with dummy guncotton as target mines, and the object of the experiment was to ascertain the effect upon the different structures of exploding heavily charged submarine mines in their neighbourhood. The targets included naval counter-mines, fixed mines, and electro-contact mines, service and experimental. The various mines were all fixed buoyantly, and were destitute of blowing-up charges, as the purpose in view was not to discover whether the explosion of the heavy mines would detonate those in their midst, but to learn the comparative effects of the concussion on the containing vessels and gear, the force of the explosives at different ranges being measured by crusher gauges. Great interest was

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manifested in the experiment, because of the fact that such heavy charges of guncotton, amounting in the aggregate to 2,000lb., and having an energy equal to about 8,000lb. of gunpowder, had not previously been simultaneously discharged at Portsmouth. The charges were simultaneously exploded from Gilkicker on a half-ebb tide. As a spectacle the effect was somewhat disappointing. The spouts of water were almost connected and were extremely jagged in outline, but they did not rise to the height expected, the stream of mud which overflowed the interior lining of the jets showing that the mines were scarcely buoyant at the time of the explosion. The detonation was not unpleasant on shore, but the radial extension of the disturbance must have been effective, as fish were stunned at considerable distances out to sea. The results of the experiment cannot yet be known.

A New Telephone Exchange.—A meeting of subscribers and others was recently held at the offices of the newly established branch of the West of England and South Wales Telephone Company, situated in Abbey-road, Torquay. The chair was taken by Mr. H. F. Lewis, general manager of the company. The chairman said he hoped to give the town such a telephone service as they would be sure to appreciate. As to the progress of telephony, England was far behind other countries, and especially New York. In one city in America there was a telephone to every twenty of the inhabitants. In London there were about 4,000 subscribers; Manchester, Liverpool, 1,200; Glasgow, 900, at £20 each; in Dundee there were 700, at £15; Bradford, 450, at £15; and Dublin, 710, at £12. At Brighton there were 120, at £12; Plymouth, 50, at rates of £12 for a year, and £11 for three or five years, and £10 for five or seven years; and Portsmouth 30, at £10 for seven years; and at Torquay there were nine already connected, and eight orders on hand, and considering the short time the company had been at work, there was fair progress. It was an entirely new thing in Torquay, and he hoped it would grow. Any exchange having under a hundred subscribers was not of very great service to the subscribers, and of very little profit to the company, and it was to the interests of the public to see in what way the number of subscribers could be increased, for the greater the number the more valuable it would be to them. The company had to pay a royalty of ten per cent. to the Post Office on the gross income, and also royalties to the United Telephone Company for the use of their master patents, viz., Edison's patent (Blake form), and the Bell receiver, so that it would be seen that out of every £10 received they had to pay between £2 and £3 royalties. The instruments in use at this exchange were similar in all respects to those in use elsewhere, and there were about 20,000 in use altogether throughout the United Kingdom. They consisted of Edison's patent transmitters and Bell's receivers, and were excessively sensitive. Owing to this sensitiveness faults occasionally occurred. At Bristol there was an average of 2,000 calls per day, which meant 4,000 communications; of this number there were only an average of four faults per day; in some cases the fault rested with new subscribers, who had not become used to the instrument. The subject had been mentioned of connecting towns together; that he thought might, and no doubt would, come later on. If a sufficient number of subscribers could be obtained the company would be glad to do so. Exeter and Plymouth might be joined up to Torquay. In reply to a question as to what distance a message could be sent by telephone, the chairman said the telephone wire from London to Brighton was fifty-two miles, and from London to Dover, during an experiment, allowing for the special resistance by working through telegraph instruments at stations which had to be overcome, the equivalent was about 280 miles. In the Midlands 156 miles had been spoken through; in America much longer distances than this have been spoken through. The company could not work at lower rates than those proposed. In New York the charge was £30 per annum, and in Paris £25; the former was, he believed, about to be raised to £40, and the latter to £30.

Institution of Civil Engineers of Ireland.—In the course of his address, delivered on the 4th inst., the president of this institution made the following reference to electrical matters:—"Electricity, which has done so much, and with which we have expected to do so much more in many various ways, has not as yet produced a storage battery which is at the same time economical and occupies but a small space. We have not as yet arrived at the time when any one can, with reasonable economy, light his house with incandescent lamps at a price which will compare favourably with ordinary illuminants; and unless the ordinary householder is capable of understanding and attending to an engine and dynamo he must yet wait before he can gain the undoubted advantage of the electric light at a reasonable cost. With large spaces and certain classes of buildings, the case is very different; and when the arc light can, either with or without a certain proportion of incandescent lighting, be used to give large amounts of light, it is found to be economical as compared with its older rival, gas. I would, however, point out that the direction in which even greater economy could be obtained seems to be in the production of cheaper but still reliable carbons. Unless carbons are of the best possible kind they flicker and give off a large quantity of dust, which gets into and clogs up the mechanism of the lamps. In order to illustrate how important is the question of the cost of carbons I may mention that in a large installation with which I am familiar the carbons cost 40 cent. of the whole expense of working; wages amount to 30 per cent.; coal to only 14 per cent.; the remaining 16 per cent. being made up of all the smaller items of repairs, oils, tallow, waste, leather belts, &c. Those who have had anything to do with the erection of electric lighting plant cannot help being struck with the number of German workmen who are employed in connection with this work, and is it no doubt due to their possessing a greater knowledge of electricity and chemistry which our own workmen have not the same facilities for obtaining; and this fact is but one of many which may be brought forward to illustrate the necessity of the establishment of technical and scientific schools in our large towns. How little has been done in England and Ireland, and how much in Germany, to foster scientific and also technical education was shown in the admirable address of Dr. Lyon Playfair to the British Association. The difficulties which exist with regard to small installations of electric light for household purposes are almost the same as those which prevent its use for the lighting of railway trains. Several experimental trains have been lit, and some of them are still running on various lines in England, with incandescent lamps. In one system an engine and dynamo is fixed on the locomotive, but the light goes out if the locomotive is detached, unless there is a storage battery in the van. In another the dynamo is driven from the axle of the van. In a third storage batteries are entirely depended on; but nothing that I am aware of has as yet been produced in a handy, and at the same time an economical, form which will enable any carriage to be detached from a train and carry its lights with it for a number of hours. What is required is something of the simplest possible character, easily attended to and not demanding of lampmen more intelligence than is now required to turn a gas tap."

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 410, Vol. XV.)

The Magnetic Field due to Impressed E.M.F.

The three sections before the last were principally devoted to the consideration of the electric field set up by impressed electric force, also as modified by previously existing electrification. There is also simultaneously a magnetic field, if there be electric current. This will depend on how the impressed forces are distribut d, which question we need not return to further than to say that should they be wholly in nonconducting regions there can be no steady current, but merely a transient one producing elastic displacement; and that if there be impressed force in a conducting region, which is the first condition for there to be a steady current, it must not be polar in its distribution therein, and with its lines perpendicular to the boundary, or there can be no current again. [The term polar force is borrowed from magnetism to signify any force whose distribution is such that its integral round any closed curve is zero. This is the most useful property by which to identify a polar force. The lines of force start from certain places and terminate at others; these places are the poles, in an extended sense; any pole, positive or negative, may be conceived to send out a definite amount of "force," uniformly in all directions, *i.e.*, according to the inverse square law. The mathematical expression is curl $F=0$, if F be polar; the boundary representation of curl F being the tangential component of F turned through a right angle on the surface. That the lines of F must be perpendicular to a series of surfaces does not sufficiently identify a given force with a polar force, as this is not inconsistent with the integral force in a circuit being a finite quantity, and so giving rise to the corresponding flux.] Thus to have current in a conductor the impressed force must have a finite value in at least one closed path entirely within the conductor. The current thus depends upon the "curl" of the impressed force. This is of great importance in the theory of the Volta force or other boundary forces. The curl of any force is always arranged in closed lines, *e.g.*, the closed line at the common meeting place of zinc and copper (in contact) and a medium surrounding them.

Supposing now the arrangement is such that there is current, the determination of the state of the magnetic field from it is, in comparison with the determination of the state of the electric field anywhere, a comparatively simple matter, the former being a reduced and greatly simplified form of the latter, with changed meanings of the quantities concerned. The flux is the magnetic induction. That has no divergence, to begin with; one simplification as compared with electric displacement. Next, there is no magnetic current, as it ceases when the state becomes steady. And, finally, the ratio of the flux to the force (magnetic), or the permeability, is everywhere finite, so that there is no division of space into permeable and impermeable regions. In brief, the full statement of the conditions is contained in

$$B=\mu H; \quad \text{div.}B=0; \quad \text{curl.}(H-h)=4\pi C; \quad . \quad . \quad (98)$$

the first being the linear connection between the flux and the force, the second expressing the continuity of the flux, and the third the relation between the magnetic force H and the current C, in which h is the impressed force of intrinsic magnetisation $I=\mu h/4\pi$. As, by the linearity of the equations, the field due to C and to h is simply the sum of their separate fields, we may put $h=0$ at once, and therefore deal entirely with induced magnetisation (*quasi*-elastic).

If we integrate the third equation (98) on this understanding, we see that H may be any vector whose curl is $4\pi C$, and is therefore indeterminate as regards a polar force, F. We have then $H=h_1+F$, wherein, on account of the presence of F, we may choose h_1 to have no divergence. It is then definitely given by

$$h_1 = \text{curl of vector potential of C} = \text{curl.}\ \Sigma C/r,$$

if r be the distance from an element of C to the place where h_1 is reckoned.

As thus defined, h_1 is what is usually called the magnetic force of the current. It *is* the magnetic force of the current if there be no variation of permeability anywhere; otherwise it is what the magnetic force would be if there were no such variation. The absolute value of the permeability, provided it be the same everywhere, is a matter of indifference, so far as h_1 is concerned. The polar force F therefore represents the change made in the magnetic force by variations of permeability, due, of course, principally to the presence of iron.

For limited purposes, h_1 may be regarded as the impressed magnetic force due to a distribution of intrinsic magnetisation $I_1=\mu h_1/4\pi$. That is, if we abolish the electic current and substitute I_1, the magnetic force and the induction would be unchanged. But whilst h of real intrinsic magnetisation may be arbitrary, and is usually in very limited portions of matter, the lines of h_1, as we have chosen it, are closed, and extend over all space in general, though by particular arrangements of current they may be shut out from certain spaces.

Let T be the total magnetic energy due to C. The two most noteworthy forms for T are

$$T=\tfrac{1}{2}\Sigma HB/4\pi=\tfrac{1}{2}\Sigma AC \quad . \quad . \quad . \quad . \quad (99)_1$$

the first summation being of the scalar product of the magnetic force and induction ($\div 8\pi$), and probably representing the real distribution of the magnetic energy; the second of half the scalar product of the current and the electric impulse A, which is excessively unlikely to be anything near the real distribution. In $(99)_1$ A may be any vector whose curl is B; but to give it the most physical significance, it is best to take it to be the electric impulse arising from inertia, or the time-integral of the electric force of induction on sudden removal of the impressed force e keeping up C. It is a scientific concept which does not express any physical state or condition. The electric impulse A at a given place does not depend upon the magnetic state there, but upon its condition everywhere; as on removal of e, disturbances are propagated to the place, these determine the electric force of induction whose time integral is A.

Other forms are useful in showing the influence of variable permeability.

Thus
$$\left.\begin{aligned} T &= \tfrac{1}{2}\Sigma h_1 B/4\pi \text{ (because } \Sigma FB=0), \\ &= \tfrac{1}{2}\Sigma h_1 J_1 - \tfrac{1}{2}\Sigma F\mu F/4\pi = \tfrac{1}{2}\Sigma h_1 J_1 - \tfrac{1}{2}\Sigma\Omega\rho \end{aligned}\right\} . \quad (99)_2$$

Here h_1 and J_1 are definitely known, by the preceding. The new quantities Ω and ρ are the magnetic potential and the volume density of magnetic matter; the polar force being the slope of Ω, or $F = -\nabla\Omega$, whilst ρ is given by

$$\rho = \text{conv. } J_1 = -h_1\nabla\mu, \text{ (when } \mu \text{ is scalar).}$$

Thus ρ exists only at places where the permeability varies, therefore mainly at the bounding surfaces of different kinds of matter, or, disregarding perfectly abrupt changes, in thin layers at the bounding surfaces.

If $\nabla\mu$ be perpendicular to h_1, we have $\rho=0$. Hence, starting with μ constant, when h_1 is the real magnetic force, if we select a complete tube of force, or any region bounded wholly by lines of force, and alter its permeability to any other value (constant throughout the region), the magnetic force will be unaltered, whilst the induction will be altered within the the region in the same ratio as the permeability. If now we choose to ignore the changed permeability, we may ascribe the altered induction to an additional electric current, on the surface of the region, perpendicular to the magnetic force and of the proper strength to produce the increased induction. In $(99)_1$, A will be altered by a quantity depending upon this false current. By adding more and more tubes of force to the region, we finally include all space, or alter the permeability everywhere in the same proportion. Then, as might be expected, the false current to account for the increased induction on ignoring the altered permeability occupies the same situation as the real, in fact increasing its strength in the same ratio as the permeability was increased.

There is another form for T which is very curious, related to the electric energy due to the same impressed electric force e. Let U be the total electric energy, then $U=\tfrac{1}{2}\Sigma ED$, if E be the electric force and D the elastic displacement. Now this last is

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the time-integral of $\dot{D}$ the transient displacement current during the charge. Let $\dot{D}_1$ be the simultaneous transient conductive current, so that their sum is the transient current of induction during the charge, a *closed* system of current which finally ceases, and which, when added to the final current C, makes up the actual current Γ at any moment during the charge. Thus,

$$\Gamma = C + \dot{D} + \dot{D}_1.$$

The time-integral of $\dot{D}_1$ is D_1, the complement of D; the two together being closed. Then, to match $U = \frac{1}{2}\Sigma ED$, we shall have

$$T = -\tfrac{1}{2}\Sigma ED_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (99)_3$$

This we may verify by a former equation. Assuming it to be true, we have

$$\left.\begin{aligned} U - T &= \tfrac{1}{2}\Sigma E\,(D + D_1) = \tfrac{1}{2}\Sigma e\,(D + D_1) \\ \text{or,} \quad 2(U - T) &= \Sigma E\int(\Gamma - C)\,dt = \Sigma e\int(\Gamma - C)\,dt, \end{aligned}\right\} \quad (99)_4$$

by definition of D and D_1, which expresses that the work done by e during the transient state is $2\,(U - T)$ more than if the current started instantly everywhere in its final distribution. This proof of $(99)_3$ therefore rests upon equation (64). But it is easily proved directly, by using the electric impulse A. Thus, by $(99)_1$,

$$T = \tfrac{1}{2}\Sigma AC = \tfrac{1}{2}\Sigma AkE, \text{ if } k = \text{conductivity},$$

$$= \tfrac{1}{2}\Sigma E\int k\dot{A}\,dt.$$

Now, let E_1 be the electric force in the transient state, *i.e.*

$$E^1 = e + f - \dot{A}, \text{ where } f \text{ is polar.}$$

Then $\qquad k\dot{A} = k\,(e + f) - (\Gamma - \dot{D}),$

therefore, $\qquad T = \tfrac{1}{2}\Sigma E\int\{k(e + f) - (C + \dot{D}_1)\}\,dt,$

by definition of D_1; and, since $\Sigma keE = \Sigma eC = \Sigma EC$, and $\Sigma fC = 0$, we are reduced to $(99)_3$ as required.

The equation $(99)_4$ may be transformed to

$$U - T = \tfrac{1}{2}\Sigma Zg \quad . \quad . \quad . \quad . \quad . \quad (99)_5$$

if we have

$$-\,\text{curl.}\,Z = 4\pi(D + D_1), \text{ and } -\,\text{curl.}\,e = 4\pi g.$$

Here g is the false magnetic current corresponding to the impressed force e, going round the lines of e, roughly speaking. And Z may be taken to be the magnetic impulse at a point, the analogue of A, as we may thus verify. By the just given equation of Z, differentiating to the time, we get

$$-\,\text{curl.}\dot{Z} = 4\pi(\dot{D} + \dot{D}_1) = 4\pi(\Gamma - C) = \text{curl}(H_1 - H)$$

if H_1 be the magnetic force at any moment during the transiont period, H being its final value. Therefore

$$-\dot{Z} = H_1 - H + F_1$$

where F_1 is polar, showing that $-\dot{Z}$ may be taken as the magnetic force of induction. Or thus: remove e suddenly, the time integral of the magnetic force in the variable state following at any point will be Z. The definition of Z may be extended so that its time variation shall be the actual magnetic force; but it is simplest, and harmonises best with the electric impulse, to make it refer to the variable state only.

Take e to exist only across a single thin slice of a wire, the most elementary case. Then g will be round the boundary. $D + D_1$ is then the integral current through g during the charge (not counting the final current, if any); or, reversed, it is the integral current through g when e is removed. If this current be oscillatory, it may amount to nothing in the total. If so, the potential and kinetic energies were equal. The value of Z at the place of g is also zero, of course, by $(99)_5$, the magnetic force there reversing with the current. (The place of g is where energy leaves the seat of e when it is working.)

Another pair of allied expressions for the parts of U and T *outside* the conductors.

$$T = \tfrac{1}{2}\int dt\Sigma\text{conv.VE}_1\text{H}/4\pi\,; \quad U = \tfrac{1}{2}\int dt\Sigma\text{conv.VEH}_1/4\pi. \quad (99)_6$$

Here E_1 and H_1 are the values of the electric and magnetic forces at time t after e was started, and E, H, their final values; the time integral to include the transient period, and the Σ being summation through the whole space outside the conductors.

By means of the convergence theorem we may at once transform these expressions to surface integrals over the boundaries of the conductors. Thus, let N be the unit normal out from conductor to non-conductor, and

$$\text{VE}_1\text{N} = 4\pi g_1\,; \quad \text{VNH}_1 = 4\pi\gamma_1\,; \quad \text{VEN} = 4\pi g\,; \quad \text{VNH} = 4\pi\gamma\,;$$

γ and γ_1 being therefore boundary (false) electric, and g, g_1 boundary (false) magnetic currents. Then

$$\left.\begin{aligned} T &= -\tfrac{1}{2}\Sigma H\int g_1 dt = -\tfrac{1}{2}\Sigma\gamma\int E_1 dt = \tfrac{1}{2}\Sigma A\gamma \\ U &= -\tfrac{1}{2}\Sigma E\int\gamma_1 dt = -\tfrac{1}{2}\Sigma g\int H_1 dt = \tfrac{1}{2}\Sigma Zg \end{aligned}\right\} \quad . \quad . \quad (99)_7$$

wherein of course the Σ's are mere surface integrals, since there only are the quantities g and γ. In the last forms, which we had occasion to employ in the last section, A and Z are, as there and in the former part of the present section, the electric and magnetic impulses. Notice, however, that the g in $(99)_7$ is not the same as the g in $(99)_5$, and there defined; the present g extending over all the boundary in general, although, should $T = 0$ (no final current), we see by $(99)_5$ and $(99)_7$ that they are then identical, situated round e, which must reach the boundary.

Here we may notice a peculiarity of interest in connection with the difference of treatment of vectors according as they are closed or polar. Suppose we have two conducting bodies in air, and charge them oppositely by an impressed force in a connecting wire. The electric energy set up is $U = \frac{1}{2}\Sigma Zg$, g being round e only. But now suppose we disconnect the wire from the bodies and take it, with e, away to a distance. We have altered the field very slightly, so that Z has nearly the same value anywhere as before, and U also. But g has gone altogether. How then does $\frac{1}{2}\Sigma Zg$ apply, the force being normal to the conductors?

Notice that, as stated in the last section, this formula only applies when it is possible to close the displacement outside the region in which U exists, so as not to pass through it and alter the field. Thus the formula applies to all the space between the two oppositely charged conductors provided we leave out a little piece joining them, along which to let the displacement return. This little piece may be reduced to a mere line, thus infinitesimally altering the field. The formula then reduces to a line integral, which will be found to become

$$\tfrac{1}{2} \text{ charge} \times \text{difference of potentials,}$$

the common electrostatic formula.

On the other hand, if we join the conductors by a wire through which they will discharge (unless balanced by impressed force in it), the formula acquires reality at once; g at first moment being at place of contact (round the spark) and thereafter over the conducting surface generally. During the discharge there will be a real magnetic current G in space, and the value of U at any moment will be $\frac{1}{2}\Sigma Z(G + g)$. (See last section, p. 409).

(*To be continued.*)

ON THE DESIGN AND CONSTRUCTION OF DYNAMOS.

BY GISBERT KAPP.

(*Continued from page 252, Vol. XV.*)

The equation $R \leqq 10^{-6}\dfrac{TNt\,n}{r_0 + r}$ is very instructive, as it shows which terms tend to increase, and which tend to reduce, the magnetic resistance R. It was pointed out in the preceding article that, on the critical point, when the speed of the dynamo has been reduced to a certain value, at which there is danger that the machine may lose its magnetism altogether, exciting power and electromotive force just balance each other without a margin on either side. This condition of things corresponds to a point on the characteristic curve fairly near

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the origin; in fact, it is that point where the curve becomes real. It is customary to represent the characteristic of a series-wound dynamo as a continuous curve from the origin to the point of highest E.M.F. and current possible in that particular dynamo. This is not a correct representation, because we are not able to maintain the current and E.M.F. steadily at certain small values between the origin and the critical condition; if we attempt to do this, the machine will either lose its current altogether or it will increase up to the critical value. If the field-magnets be of cast iron, the critical point will naturally lie nearer to the origin, because of the residual magnetism in the field, which facilitates the starting of the current. With wrought-iron field-magnets the critical point will be reached later; but, on the other hand, the characteristic has a more decided upward slope, rendering the machine more suitable for compounding. From the above expression it will be seen that the critical magnetic resistance R may be the greater the more wire is coiled on armature (Nt) and magnets (T) and the higher the speed (n), and that it must be the smaller the greater the electrical resistance of the machine or the outer circuit. In a given dynamo R is fixed by the constructive features of the machine, and the only variables in the expression are n and r. The former we call with Marcel Deprez the *critical speed*, and the latter might be termed the *critical external resistance*. It will be understood that either of these values only becomes critical if the other is arbitrarily fixed. Suppose the external resistance to be fixed, and we wish to know the speed at which the machine will begin to excite itself and give a current. The above equation for R gives

$$n = 10^6 \frac{R(r_0 + r)}{T\,Nt}.$$

If, on the other hand, the speed be fixed, and we require to know the greatest resistance which can be put into the external circuit, we find

$$r = 10^{-6} \frac{T\,Nt\,n}{R} - r_0.$$

It is of course desirable to keep the speed of dynamos low, and yet obtain the full electrical output. As regards the latter point, this in series machines is equivalent to a high external resistance, for the strength of the current is limited by the condition that the armature and magnets should not become too hot. Apart from this, series dynamos are mostly used for arc lighting, and for the satisfactory working of the lamps the current should be as much as possible constant, whatever be the number of lamps in circuit at a time. It will therefore be correct to say that in series machines the output is proportional to the external electromotive force, and consequently it will be a maximum if r is a maximum. We have thus the conditions that n should be as small and r as large as possible. These will be obtained if the magnetic resistance is low, if the number of turns of wire on armature and field-magnets is large, and if the internal resistance of the machine is small. The latter two conditions are to a certain extent contradictory, but by using comparatively large wire a compromise can be arrived at. To make the magnetic resistance low, each of the three terms R_A, R_F, and R_a must be small. By referring to our last article it can be seen that each of these resistances is of the character length divided by area, and that R_a, the air resistance, is by far greater than R_F, that of the field-magnets; and the latter is generally greater than R_A, that of the armature. Consequently a reduction of R_a will have most influence in diminishing the total magnetic resistance. The expression for R_a was found experimentally to be

$$R_a = \frac{1440\ 2\,\delta}{\lambda\,b}.$$

In order to make it small we must have δ, which represents the distance between the polar surface of the magnet and the surface of the armature core, small. We must also have b and λ large. The former represents the length of the armature, which we suppose to be of the cylindrical pattern, and the latter the arc spanned by either pole piece. The product $\lambda\,b$ is the surface of one pole, and to make this large it is evidently necessary to have a large armature. Similar considerations apply to disc armatures, the only difference being that b in this case represents the radial depth of the disc, which has to be taken twice, once for each side, and λ the mean width of pole pieces. A large armature gives a low magnetic resistance of air space—first, because of the large polar surface through which the lines can pass without unduly crowding each other, and secondly because the necessary number of turns Nt can be spread over a larger surface, whereby the thickness of winding, and therefore the value δ is decreased. The lower the magnetic resistance of a dynamo, the less electrical energy is required to excite the field-magnets and the more economical is the machine. This follows also from the above formula for r. In a series dynamo the electrical efficiency μ is the ratio of the external to the total resistance

$$\mu = \frac{r}{r + r_0}.$$

We find from this equation

$$r = r_0 \left(\frac{\mu}{1 - \mu} \right),$$

and substituting this value into the expression for r we obtain

$$\mu = 1 - \frac{r_0 R}{10^{-6}\,T\,Nt\,n}.$$

The larger R, the smaller will naturally be μ, and we find that dynamos with comparatively large armatures are more economical than those with small armatures. In connection with this matter an interesting question presents itself. Suppose we have a series wound dynamo giving a certain output with a certain electrical efficiency, and we wish to make a small model of that machine, what will the output and efficiency of the model be? We suppose that in the model the linear dimensions are reduced in the ratio of K : 1, and that the same numbers of turns of wire are wound on field and armature, but that the gauge of the wire is $\frac{1}{K}$ times that of the real dynamo. In making this assumption we are going probably beyond what is practically possible, for the thickness of the insulation on the wires cannot be reduced in the same proportion as the gauge itself; but in order not to complicate the problem too much we will assume that by the substitution of silk for cotton, and by very careful covering it were possible to make the thickness of insulation in the model $\frac{1}{K}$ times that in the dynamo. We will also assume the workmanship in the model to be so perfect that the clearance necessary for the safety of the armature need only be $\frac{1}{K}$ times that of the dynamo. Since each turn of wire on the dynamo is K times as long as on the model, and since an equal number of turns is employed, the electrical resistance of the model will by reason of the reduction in the total length of wire be $\frac{1}{K}$ times that of the dynamo; but, on the other hand, the area of the wire in the model is only $\frac{1}{K^2}$ that in the dynamo, and this will increase the resistance K^2 times. The electrical resistance of the model r'_0 is therefore K times that of the dynamo. The same reasoning holds good with regard to the magnetic resistance. All the lengths are reduced K times and all the areas K^2 times, making the magnetic resistance R^1 of the model K times as great as that of the dynamo. If we wish to have an equal factor of safety with regard to centrifugal force—which tends to burst the armature—in the dynamo and model, the circumferential speeds must be equal. We may therefore allow the model to run K times as fast as the dynamo. The external resistance through which the model can send a current and excite itself is

$$r' = 10^{-6} \frac{T\,Nt\,Kn}{K\,R} - r'_0,$$

$$r' = \frac{10^{-6}\,T\,Nt\,n}{K} - K\,r_0.$$

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The first term on the right hand side of this equation is identical with that obtained for the dynamo, and we can also write

$$r' = r - (K - 1)\, r_0.$$

It will be seen that r' decreases rapidly with an increasing K. The efficiency of the model is

$$\mu' = \frac{r'}{r' + r'_0},$$

and, by substituting the values for r' and r'_0, we can express the efficiency of the model in terms of the efficiency of the dynamo and of the factor of reduction K

$$\mu' = 1 - K\,(1 - \mu).$$

This equation is very instructive, because it shows what influence the reduction of the linear dimensions of the dynamos has on the efficiency. The more we reduce the size, the less efficient will be the model, and there is evidently a limit for which $\mu' = 0$, and in this case the model will have just sufficient power to magnetise its field-magnets with short circuited terminals, but it will not be able to do external work. If we reduce the size further, the model will not even have power to excite itself, and it will altogether cease to act as a dynamo. The limit occurs when $1 = K\,(1 - \mu)$.

If we reduce the linear dimensions of the dynamo in the proportion of $K = \frac{1}{1 - \mu}$ its efficiency will be zero, and it will not do any external work.

The same result is obtained from the equation for r' by putting $r = (K - 1)\, r_0$. This gives as the limit of reduction

$$K = 1 + \frac{r}{r_0}.$$

An example will make this matter clear. Say we have a dynamo the armature of which is 5″ in diameter, and which is found to work at its critical condition with an efficiency of 80 per cent. In this case $1 - \mu = 0{\cdot}2$, and $\frac{r}{r_0} = 4$. These values inserted into the above equations for K give both $K = 5$.

If an amateur electrician were to make a model of that dynamo one-fifth the natural size, he would find that he could not get it to work. He would have to increase the size of the armature out of proportion with the rest of the machine in order to obtain a working model.

What has here been explained at some length for a series-wound dynamo also holds good for a shunt-wound dynamo, the only difference being that instead of $r + r_0$ we must insert $r\,s$, the resistance of the shunt coils in the formula for R. It can also be shown that the efficiency depends on the magnetic resistance in the same way as in series dynamos, and that the larger the dynamo the greater is its electrical efficiency.

We need not discuss the question of shunt dynamos at length, because it would be partly a repetition of what has already been said; but it will be necessary to investigate the relation existing between the size of dynamos (series-shunt or compound-wound) and the electrical output they can give without undue heating. This is a more general question of great practical importance, and includes that of efficiency just discussed.

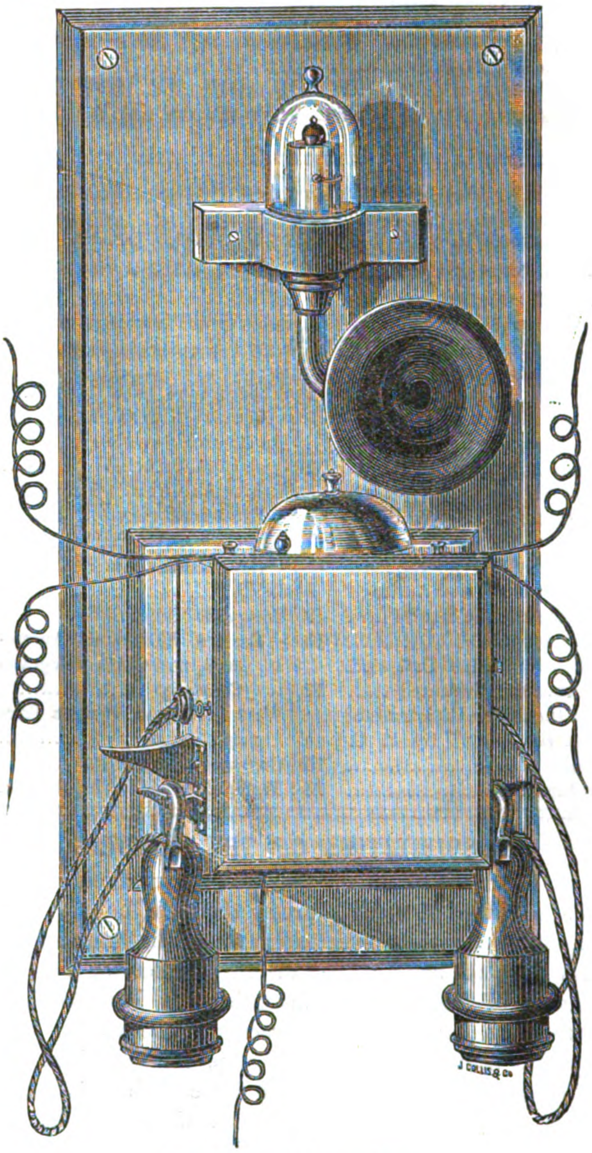
(To be Continued.)

THE THOMPSON MICROPHONE.

In this microphone, the invention of Professor Silvanus Thompson, it is claimed that a diaphragm is dispensed with; but it is open to question as to whether this is really the case.

Of the merits of the instrument itself we are unable to speak with any degree of confidence, in that we have been unable to obtain any more definite information in regard to it than is to be gleaned from an inspection of its exterior. It is probable, however, that the articulation is clear, though necessarily, we think, weak. Its construction will be readily understood from the diagram, a principal feature being the small carbon cone at the top of the instrument, as shown and fitted.

Professor Thompson, like many other people who have gone before him, has apparently been unable to do more than modify existing apparatus. This modification may or may not be, scientifically speaking, a valuable one. We suspect not. Mr. Irish, of Sunderland, exhibited something of the kind a little time ago, but we believe his patent was taken out subsequent to that of Prof. Thompson. We do not mean by this that Mr. Irish was guided in any way by the knowledge which might in that way have accrued to him; far from it. Mr. Irish's microphone, however, was based upon similar but much more ingenious lines.



The Thompson Microphone.

Instead of using a cone fitted as in the Thompson microphone, he employed a small carbon ball about ¼in. in diameter, placed upon three carbon supports arranged in the form of a cone—that is to say, being about 1½in. apart at the base, and approaching to something less than ¼in. at the apex. There was, however, this advantage, the instrument could be reversed and the ball inserted from the broad end of the skeleton cone, or the cone and ball suspended in any desired position, occupying but the space of a few inches, and doing all we can with reason expect from the more elaborate arrangement of Prof. Thompson.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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VOLUME XV.

Volume XV. of "The Electrician," price 10s. 6d., will be ready next week. Also cases for binding, price 2s.

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POSSIBILITIES OF THE FUTURE.

If we could but eliminate the solid facts which contribute to the bursting of many a pretty theoretic bubble, through what a vista of roseate anticipation would the future of science be revealed to mankind. Excepting in one or two things, the march of discovery and invention has been too slow to create much excitement. The process, in the natural order of things, has always been step by step, and the minds of men have been so gradually prepared for each benefit conferred upon us by science that the element of surprise has never risen to any great proportions. When Jules Verne wrote his description of the "Nautilus," the strangeness of the idea seized upon everyone. The author had, however, merely collected together a number of theories, both old and new, and by omitting some of the more important causes which would contribute in each case to failure, clothed his conception in a seemingly practical garb. Swift's account of the Island of Laputa was based upon a curiously distorted theory of magnetism, sufficiently *possible* to give it universal interest; and Bulwer Lytton's "Coming Race," in so far as Vril is concerned, turns upon little more than the successful storage of electricity of high potential.

At the present moment we are much given to laughing in our sleeves at the credulity of non-technical people with regard to electrical wonders. We should remember, however, that dreams sometimes come true; that only a few years ago the same sneers and the same scepticism greeted the forecasts of what are now recognised institutions among us; that the impossible is comparative—belonging to an age but not to all time; and that the gift of prophecy attaching to the best of us is constantly baffled by the occurrence of the unexpected. It is not long since a terrible outcry was made about the exhaustion of our coal. People wondered, and wonder to this day, what on earth we are going to do when that familiar and exceedingly dirty mineral sings its death song and resolves its last substance into air. The answer is easily found—we shall burn something else! What? Oh, anything. Petroleum; electricity; hydrogen and oxygen from water. There is plenty of water in the ocean, and we are equally unrestricted as to air. For purposes of locomotion compressed air is getting itself into notice. The loss of coal need not disturb us; when the time comes, we shall be surprised at our own folly, not only for grieving at the thought of its decease, but for ever having used it.

Many strange discoveries, however, will probably greet humanity ages before the collier betakes himself to a more cleanly occupation. It will not be many years, we imagine, before we have a complete and efficient domestic electrical system, lighting and warming our houses, driving the sewing machine, and all other homely appliances; connecting us up with the butcher, the baker, though, for obvious reasons, not then with the candlestick maker; making the coffee and toast in the morning, rocking the cradle at night, and, in fine, doing a thousand and one things that will not only render the demon domestic a creature of the past, but confer upon us a period of rest that will be a foretaste for some and a consolation for all. At intervals along the streets of our great cities we shall have "call boxes," by means of which conversation, by telephone, may be carried on with *any* desired person without trouble or formality; the postman will no longer collect and deliver the letters, a network of pneumatic tubes providing for that. All you then need do will be to drop the epistle in your domestic letter-box and manipulate a knob. When a letter arrives a bell will ring, and the impact of the missive will immediately cause it to be placed in full view upon the hall table. If there is not an abundance of Vril it will be no fault of electricians.

These are only one or two of the things which will happen. Outbreaks of fire will be rendered impossible or harmless. Robbery and violence will be minimised by a thorough employment of the electric light and an excellent system of electrical police calls, placed anywhere and everywhere within reach. A policeman guaranteed on the spot within five seconds. Impossible! Well, perhaps, this is the one thing we are doubtful about. Laputa will be rediscovered. Balloons, electrically navigated, will run regularly between this country and other parts of the world, at reasonable charges; but intending defaulters will notice that in consequence of the recently improved method of telegraphic communication between us and these aerial *voyageurs* there is no additional safety from the clutches of the future cosmopolitan detectives offered by this mode of flight.

This last reflection is saddening. Everything mundane has its drawbacks. Perhaps a general increase of honesty will negative *this* one. We say perhaps, because recent experience seems to indicate that there is just as much right down solid fraud connected with the electrical as with any other industry —and a little more. Dreams, idle dreams. However pleasant a contemplation of the possible future may be found, the stern records of failure which, with the brief chronicles of success, have to be written down on the pages of the world's history,

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consort but ill with the speculative fancies of an enthusiast. Nevertheless, as we write these lines at the beginning of a new volume, we feel how rash it would be to assert that even the most fantastic of dreams may not be realised before its conclusion. There are already some signs that this may come to pass. Petroleum has lately been successfully tried as a substitute for coal in our steam navigation; and Nordenfeldt's submarine boat bids fair to compete with the "Nautilus" of an extravagant fiction.

CORRESPONDENCE.

HIGH-SPEED ENGINES AT THE INVENTORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The difficulties which have attended the use of many of the high-speed engines at the above Exhibition (professedly an Exhibition of Inventions) have been due, I think, to the inexperience of many of the makers, and to the stiong temptation which such an Exhibition offers to inventors to bring forward crude and untried forms of engine, rather than to anything radically wrong in the principle of high speed.

It is, I think, to high speed in the sense of a great number of admissions of steam per second that we must look for one of the greatest economies in the steam engine of the future.

I have never advocated the highest speeds because I am aware of the difficulties attending their use, but I have plenty of experience of engines running at speeds of 600 revolutions with a stroke of 6in. I believe that such speeds, which are suitable for most modern dynamos, can be economically maintained.

The strains which are imposed upon the parts of high-speed engines are easily calculated, although I agree with you that they are in many cases greater than is supposed. It is to the fact that sufficient cushioning power is frequently not provided, and that the crank has in many cases, as you say, to pull the connecting rod after it as well as push it, that many failures are due, especially where the engine is used in connection with a condenser.

I think that the data which you quote in order to show the difficulties attending high speed are rather unfortunately chosen. They are not, as you say, usual proportions for high-speed engines; but they are very usual ones for locomotives; in fact, the difficulties represented by the use of a stroke of 18in., in connection with a speed of 250 revolutions per minute, are encountered and overcome in designing the great majority of the locomotives in this country.

The cushioning power required in such cases is about half that which is required in the case of my own engines, cited above, the cushioning power required varying as the square of the number of revolutions and as the stroke, if the weights remain constant.

A speed of 390 revolutions per minute and 20in. stroke is by no means unusual in some of Mr. Webb's engines on the London and North Western Railway, and the difficulty in this case of providing suitable cushioning must be nearly three times as great as that in the case which you took for your text last week.

The velocities look rather terrible in decimals of a second, but both engines and engineers rapidly become accustomed to them if—and this is the really important part of the matter—the cushioning question is carefully looked into. In an engine running at 600 revolutions and 6in. stroke the total pressure required to keep the connecting rod on the crank pin amounts, when the crank is turning the centre, to nearly thirty times the weight of the moving parts, and to arrange for this compression economically, in a compound engine and under varying conditions of load, is not always very easy. The engines at the Exhibition were not, as a rule, working under widely varying loads, and in this sense they only met with a part of the difficulties encountered by high-speed engines in practice; but I think that in dealing with the subject you might fairly have given credit to those high-speed engines, and there were several which ran through the Exhibition with as little trouble as their slow-speed neighbours.—Yours, &c.,

P. W. WILLANS.

Ferry Works, Thames Ditton, Surrey,
9th November, 1885.

THE RESISTANCE OF CARBON RODS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can any of your readers kindly tell me where I can get any information about the variation of the resistance of carbon rods with different amounts of current passing, or at different temperatures?—Yours, &c., T.

THE STEAM ENGINE INDICATOR.—VIII.*

BY AMICE.

We may now assume that we are prepared to take an indicator diagram, and to gather from it the indicated power of the engine from which it is taken. Although this is but a small part of the purpose and value of an indicator diagram, we will deal with it first. Later on we shall consider how the information obtained from the indicator can be made available for understanding the behaviour of steam in the cylinder, and for interpreting the peculiarities which determine the efficiency of the steam engine, and the proper design and adjustment of its parts.

We will take as a first example a diagram (Fig. 33) made five years since from one of the last, if not the last, remaining atmospheric engine, and one which, therefore, is of some historic interest. The engine was apparently a Smeaton atmospheric engine, although it had subsequently been improved in some details. It was at work at the Handley Wood coal pit of the Staveley Company until November, 1879, and the date on its cylinder was 1776. It had thus been in existence and at work for the greater part of a century. At the time of its removal an engraving and description of this hoary but hale old relic was published in our contemporary, *The Engineer*, from which this typical diagram of an engine of the low pressure type—a type that did good work—has been copied, and provides us with a fit primary example. The engine had a cylinder 48in.

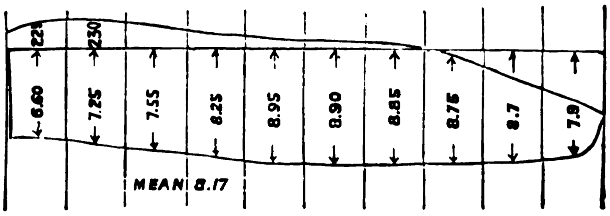

FIG. 33.

diameter, and therefore of 1809·56 square inches area. The stroke was 5·4ft., and during the time the diagram (Fig. 33) was taken the engine made 19 strokes in three minutes, or 6·33 per minute. The steam was supplied by two egg-ended boilers, in which the pressure was about 14lb. per square inch only a few feet from the engine, but, as will be seen, the maximum pressure above the atmosphere was about 2·30lbs. per square inch. The necessary pressure was not great, as all that was done in the steam stroke was to get the piston to the top of the cylinder, and the pumps it worked, in position for the down or working stroke, effected by atmospheric pressure. The diagram has been divided into ten equal parts, and the mean pressure in each part marked therein. From the diagram it will be seen that the steam never rose in the up stroke of the piston above 2·3lbs, cylinder condensation being enormous, while in the first part of this stroke it did not rise even to this. As the piston

* For Art. 7, see *The Electrician*, 28th August, 1885.

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rose the pressure fell, until, when the piston was at the top of its stroke, exhaust having taken place, the formation of a vacuum had commenced, and in the first tenth of the down stroke had reached 7·9lbs. below the atmosphere, so that the atmospheric pressure was made use of to that extent. This pressure grew, or in other words the vacuum improved, until about mid-stroke it reached 8·95lbs., from which point it fell to 6·6lbs. at the end of the stroke. In this case it is only the vacuum or atmospheric pressure which is credited with doing the work, as the down stroke of the piston is the stroke which raises the water or in which useful work is done, the engine and pump being so nearly balanced that only a very slight pressure should be necessary to raise the piston. The pressure shown above the atmospheric line A L is therefore the friction part of the diagram, and shows the amount of power necessary simply to put the engine and pumps into motion. The ten pressures below atmospheric pressure shown by this diagram, which was taken by a 10lb. spring or a spring which compressed 1in. for each 10lb. of pressure, and thus showed 1lb. pressure for each 0·10in., give a mean of 8·17lb. per square inch, so that the work done upon the piston by the atmosphere in the down stroke, that is in the effective working stroke, was

$$\frac{5{\cdot}4 \times 6{\cdot}33 \times 48^2 \times 0{\cdot}7854 \times 8{\cdot}17}{33000} = 15{\cdot}83,$$

indicated horse-power. The network represented by the water raised by the pumps was 10·05 horse-power, so that the effective work, was of the indicated work, as much as 63·6 per cent. Speaking of this result and of the engine, *The Engineer* remarked :—"Considering the condition of the engine, its disrepair (permitted because its days were numbered), the fact that a 1in. water pipe had to be kept running, nearly full bore, into the cylinder, and about 1ft. of water maintained on the top of the piston, to keep it air-tight. . . . it may be considered that the old engine did not do so badly." Here it must be remarked that the up-stroke of the piston is what is called in pumping engine house language the outdoor stroke, the down stroke bringing the pump bucket up or towards "indoors." This will make what follows clear. After the above diagram was taken "the piston was repacked with a view to lessening the condensation of steam during the outdoor stroke. The hemp was taken out, and some packing with india rubber core put in. With this packing the condensation was less and the vacuum slightly improved, but the tightness of the piston in the cylinder so increased the friction that a much higher steam pressure was necessary to get it out of doors. In a few hours, however, it wore easier, and diagrams, of which the annexed Fig. 34 is an example, were taken." This

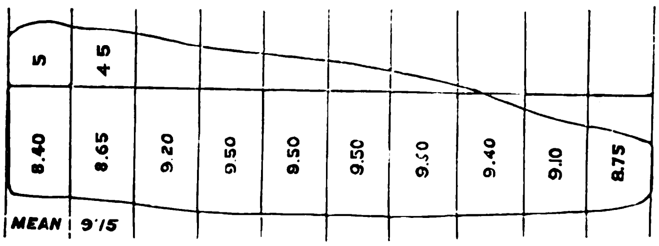

Fig. 34.

diagram we give as affording an excellent example of what may result simply from extra friction caused by tight packing, and of the way in which an increased indicated horse-power may be accompanied by no increase of actual power or of work done. From Fig. 34 "it is seen that with only the same boiler pressure, the pressure in the cylinder is nearly double what it was when so much water passed by the piston during its up stroke. The vacuum is improved, so that the mean effective atmospheric pressure, shown by the indicator diagram, was 9·15lb., the indication of the vacuum gauge reaching 19·5in. Even under these conditions, however, only 17·5 strokes were made per three minutes, or 5·83 per minute. The work done on the piston was in this case, then,

$$\frac{5{\cdot}41 \times 5{\cdot}83 \times 1809{\cdot}5 \times 9{\cdot}15}{33000} = 15{\cdot}80$$ horse-power, or practically the same as before, a result which might have been expected from the recorded experience of the use of atmospheric engines in days gone by, when it was often noticed that what might be called a considerable leakage past the piston was rather beneficial than otherwise." This, it must be observed, was not because the admission of water into the cylinder was itself advantageous, for, on the contrary, it was very wasteful, but it did not cause so much loss as a tight packing in a cylinder that was perhaps an inch out of truth in a length of three or four feet, and very rough also.

These diagrams will afford some idea of the way in which the indicator served to throw light on the work done by atmospheric engines, for, with only about 15 indicated horse-power from the old engine referred to, in its dilapidated state, about 800lbs. of coal were burned per hour, or about 50lbs. per indicated horse-power, representing, with the boilers in use, about 300lbs. of steam per indicated horse-power, or more than twelve times as much as an ordinarily good high-pressure engine of modern make would require. Thus the indicator diagram without other information would show very little. These diagrams might be supposed to show very good performances, and without any knowledge of their history would be considered fairly good, although it is clear from them that from whatever engine, the vacuum is not as good as it should be and that towards the end of the stroke the vacuum decreases instead of being maintained at its maximum. In Fig. 33 it falls from 8·95 to 6·60, indicating a heavy leakage past piston or valves or in the condenser somewhere.

In other words, the diagrams, without full information concerning the engine from which they are taken, show very little more than pressure and its variation, and the difference between Figs. 33 and 34 would indicate difference in external load upon the engine, which is not true, as the difference is only that due to internal friction. With the knowledge of the engine and its condition of working, we see that steam pressure, which should not exceed a few ounces in the up stroke, reaches several pounds; we know that within a fraction all the work done, as indicated by that part of the diagram which is above the atmospheric line, is lost work, inasmuch as the pressure on the up stroke of the piston is not conveyed to or used in working the pump, the connection between engine beam and pump being flexible and incapable of transmitting downward pressure to the pump rods. If the connection between engine beam and pump rods had been rigid, so that the pump rods could have been lightened and required forcing down, and required, therefore, so much less to lift them; or if the beam had been loaded with a weight which in the indoor stroke would have acted in concert with the atmospheric pressure, then steam pressure in the top of the diagram might have done useful work; but this was not the case. The top of the diagram shows nothing but engine friction or lost work. If this top part of the diagram, or rather its amount, be deducted from the lower part of the diagram, the amount of external work done by the engine should be the result. A glance at the diagrams will show roughly that this is the case. The net work represented by the weight of water raised is very nearly two-thirds of the indicated work. If to this net work the friction of the water through the pipes and pump valves be taken into account, the diagrams would agree with the actual work. Or, on the other hand, if we reduce the lower part of the diagram to that which would represent the 10·05 horse-power above mentioned, and then deduct the amount of the top part of the diagram, we should have remaining a small balance of indicated power which would be the equivalent of the friction external to the engine and its connections, or the friction of the water in the pump pipes and valves.

It will be seen that in these diagrams the pressure in the up stroke falls below the atmospheric line, the inertia of motive of the engine and its connections being sufficient to perform the upper quarter of the stroke.

Our first actual diagrams have thus been from the earliest type of engine, engines nominally working with atmospheric pressure only. We shall next deal with diagrams from engines which do not make any use of the atmospheric pressure.

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ON THE INSULATION RESISTANCE OF AN EARLY CABLE.

BY F. C WEBB, M.I.C.E.

The figures expressing the resistance of the dielectric of submarine cables have been published as far back as 1859, when, as I have shown in my "Old Cable Stories Retold," Messrs. Siemens and Halske, adopting the Wheatstone bridge with high resistances, measured, by bridge test, the resistance of the dielectric of the Red Sea and India cable.

The insulation resistance of the dielectric of a cable long previous to the bridge test, and therefore much earlier than the test by a Thomson galvanometer, is, however, not so easily to be found. I have, however, succeeded in working out—roughly, it is true—the dielectric resistance of the first two cables laid in 1853 between Orfordness and Schevenengen, in Holland; and the result, I think, will be of interest to electricians, as it shows how vastly superior the insulation obtained now is to that which existed at the above date. I will now explain the process:—

1. Two hundred and thirty-one miles of cable tested for insulation gave 20 degrees deflection on an upright galvanometer with a battery-power of 18 batteries of 12 plates each (or 216 elements).

2. Seventy statute miles of the conductor (which was No. 16 B.W.G. copper wire) gave also 20° deflection on the same galvanometer with one element battery power, that length being selected because it gave 20° from a tabulated statement showing the deflection with one element, with conductor in circuit, taken as every ten miles were added to the circuit.

3. Now, the resistance of a pure copper wire of No. 16 B.W.G. is about 13 ohms per statute mile; but the copper used in cables in 1853 was anything but pure, and, supposing it had a resistance of, say, 33 per cent. more than pure copper—and some coppers tested at even a much later date had just *double* the resistance of pure copper—we may take 20 ohms as the resistance per statute mile of the No. 16 copper wire used in the Hague cables. Consequently, 20 multiplied by 70 gives 1,400 ohms resistance, and this, therefore, forms the resistance for constant; $1,400 \times 216 = 302,400$ ohms, the absolute resistance of the dielectric of the 231 statute miles, and, consequently, $302,400 \times 231 = 69,854,400$, or about 70 megs, as the resistance per *statute mile* at the temperature at which the test was made.

Now, the tests above quoted were taken on the first two Hague cables, when lying under water in the tank constructed by me at Messrs. Newall, Liddell and Gordon's works at Sunderland, in February, 1853. The temperature I cannot give, for we knew nothing in those primitive times about the great difference in the conduction of gutta percha according to the temperature, and, consequently, I never employed thermometers. We may, however, assume that the temperature of the water was about 50° F., and therefore correcting for temperature we get

Log .... 70 $= 1{\cdot}84509$
Log coefficient for temp. 50° F. = $\overline{1}$ 84061

$1{\cdot}00448 = 13$ megohms per statute mile,

or, dividing by 1·15, we get 11·3 megohms per nautical mile.

LITERATURE.

Manual of Telegraphy. By W. WILLIAMS, Superintendent, Indian Telegraphs. Illustrated by 93 wood engravings. [Longmans, Green, and Co. 1885.]

This is a book which has long been needed. It is singular, though quite true, that books suitable for practical men, dealing clearly with practical difficulties, are almost entirely wanting in every branch of applied science. Text books for schools and colleges, or rather for examinations, text books dealing wholly wlth scholastic problems aie as thick as fallen leaves in autumn. The latter books have their uses, but their value is hardly to be compared with that of a really practical treatise. Thousands *believe* they can write a school book—tens might be trusted to creditably complete the task—but few men can be found to attempt the practical works.

Contact with the actual work brings out hundreds of little details that only approximate to theory, leaving an ample margin for personal cleverness to shine. Theory says so and so will happen if so and so be done. Practice says so and so cannot be done, and therefore the theoretical so and so cannot happen. Practice walks, however, in the direction pointed out by theory, gaining a step here and a step there, ever advancing towards the goal, which is still in every scientific application at an almost infinite distance. Theory, then, is one thing, practice is another. The student when he leaves his books and enters the workshop is amazed to find a new field of study opened. He comes to his work expectant, exulting in the thoughts that science has shown how to achieve perfection, only to find experience impotent to overcome practical difficulties arising in every direction.

The book before us deals with the instruments in use, describes their parts and connections, points out their defects and how best to overcome them. It should prove the guide, philosopher, and friend of the initiate in telegraphic work. It is seldom in noticing books that mention is made of the price at which the book is issued; but this seems an exceptional case in all respects. The work has been written under the auspices of the Indian Government, "by order of the Director-General of Telegraphs;" therefore the same strict attention has not necessarily been paid to the merely commercial question as is usual with books of this class. We have no doubt, however, but that the commercial result will amply repay all the care taken in the production of the work. The side notes and references are very copious, the diagrams and illustrations are very good and clear, and the book is well printed. Many books, perhaps, have more illustrations; but in the majority of instances the accompanying text is written to the illustrations, which have been borrowed or bought second hand in every direction. In the work before us the illustrations have evidently been prepared specially to illustrate what the author has to say, and this we emphatically assert is the only method which enables the author to appear in his best manner. We have to thank the Indian Government for giving us the excellent volumes of Schwendler, followed by this of Mr. Williams, which is, if possible, still more valuable.

The book is divided into six sections, each section treating a separate branch of the subject, with an appendix containing two other sections. The practical matter is put first, the laws and principles and the mathematics of the subject being relegated to the appendix. The great value of the work is that it tells you why and wherefore certain directions are given. Thus, in the construction of the Minotti the advantages of sand or sawdust as a diaphragm are discussed. The wire contact with the copper is made by hammering, not soldering, because "the latter would set up local action;" the wire is insulated right down to the disc, "to prevent the bare copper wire being eaten away by the corrosive action within the cell;" the cell should be put into the place it is permanently to occupy before the water is added "to avoid shaking up the solution." These are but a few examples of the care taken to tell the students the "why" of the action prescribed. The section on the setting-up and connecting-up of the various instruments used is excellent, and the diagrams fully illustrate the text. The same may be said of the chapter on testing instruments. We cannot direct attention, however, to each section and sub-section, but may briefly describe what seems to be the plan of the work. The author first treats of definitions and notation and nomenclature, then of batteries and instruments used in practice to perform the signalling; afterwards discussing the instruments used in testing, &c. Telegraphic circuits form an important section, wherein the method is followed of proceeding from the simple to the complex. A chapter on faults is succeeded by one on testing, while, as we have previously said, the appendix treats of the principles and the mathematical proofs of the various formulæ used in practical work. Everything is done throughout the book—both by author and printer—that is

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calculated to aid the reader to get at the root of the matter. The subject matter of the sentence or paragraph has distinctive type, while the solution of each formula is on a separate page, given with enunciation and proof, like a problem from "Euclid." Probably no other person ever agreed entirely with the matter and method of an author; but we shall be surprised if adverse criticism of any portion of this book is not silenced in the admiration which, on the whole, cannot fail to be given by those who may read it.

UNDERGROUND AND OVERHEAD WIRES.

We illustrate below Brooks's system of underground and of overhead wires. Fig. 1 shows the construction of

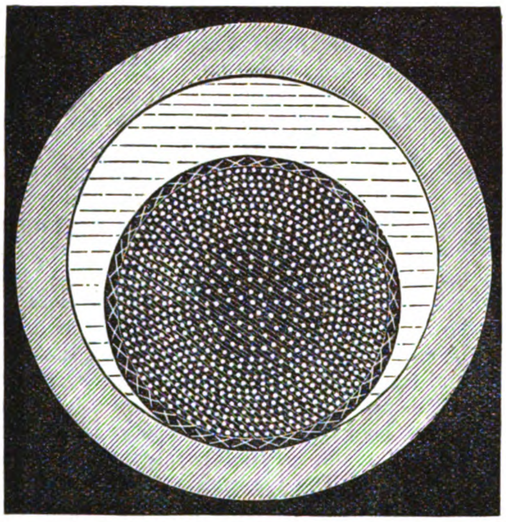


FIG. 1.

a system of 420 telephone wires in a 2¼in. pipe, as laid for the Metropolitan Telephone Company of New York. There is an outside wooden box, not shown in the figure, filled with

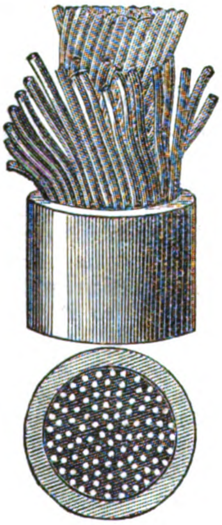


FIG. 2.

FIG. 3.

asphaltum or pitch. The dark shading shows the pitch, filling the box around the pipe. The light ring, next the pitch, represents the wrought iron pipe, inside of which rests the cable, showing the ends of the copper wire surrounded with the insulating oil, which fills the pipe full at all times. Figs. 2 and 3 represent the construction of the Brooks's overhead anti-induction lead covered aerial cable, for telegraph and telephone purposes, carrying 50 and 100 conductors respectively.

AN ELECTRIC GOVERNOR FOR STEAM AND FLUID ENGINES.

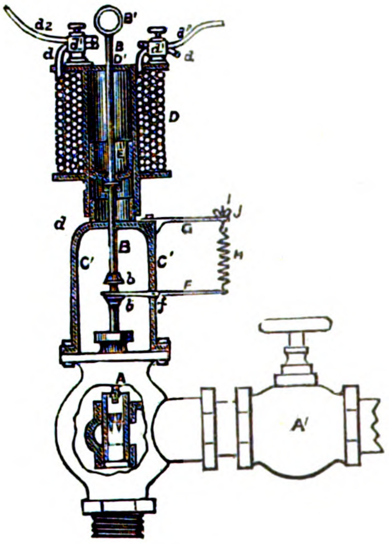
The following interesting description of a new governor appears in the *American Engineer* :—

We herewith present an illustration and description of a new electric governor for steam engines recently patented by Mr. A. L. Ide, the well known engine builder, of Springfield, U.S.A.

The invention embraces the novel feature of adjustability, whereby the governor may be readily adapted to varying requirements of intensity in the electric current by which it is operated. By this means a greater or less intensity in the lights may be obtained, and the number of lamps in the circuit may be varied from time to time, as occasion may require, while the same governor, by means of the adjusting feature referred to, is capable of being adapted to various conditions.

The distinctive feature of the governor valve is its adaptability to close the steam passage by an extreme movement in either direction.

The accompanying cut shows the governor valve located in the steam-supply pipe of an engine, combined with the electric mechanism and adjusting devices by which the position of the valve is controlled in the operation of the electric current.



A is the governor valve, and A' is the stop-valve of the steam-supply pipe. B is the stem of the governor valve. C is the arch. D is a hollow helical electro-magnet surmounting the arch, and E is an armature attached to the stem B, and adapted in form and position to enter the spool of the magnet D.

The engine with which the governor is to be used is supposed to drive an electric generator or dynamo of any form, which dynamo may be used exclusively for the purpose of operating the governor, or it may also be connected to supply any desired number of electric lights, or to do any other form of work for which such apparatus is required or adapted. The method of connecting the helix D of the governor in the current from the generator is sufficiently indicated.

The valve shown has the special feature of being able to close by an extreme movement in either direction. It consists of an open ended cylinder provided with openings through its sides in its middle portion, and seated within two cylindric seats embracing its opposite ends, said seats being cast in the same piece, but separated by a passage by which the steam is admitted around the central portion of the movable valve between the seats, so as to enter the ports, and find escape at opposite ends of the valve. The valve and its seats are inclosed within a globe-shell in the usual manner of this general class of valves. The valve can be operated to partially shut off the steam from the engine by a movement in either direction, and

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will be perfectly closed when the central ports are brought wholly within either the upper or the lower cylindric seats. The cylinder is of course constructed of such length that when the central ports are brought into either seat so as to close them the other end at the same time protrudes into the opposite seat and cuts off the supply of steam.

In the application of this valve to the purposes of an electric governor, as herein contemplated, it is designed that the ports of the valve shall work in connection with the upper cylindric valve-seat, said ports being closed more or less as the valve is thrown upward by the action of the electric current through the magnet; but it is also contemplated that after the engine is shut down, by closing the stop-valve A' in the usual way the valve shall be forced downward so that its ports are closed within the lower seat. In case the electric current is broken, or in case the driving belt of the engine is broken, the valve will be closed by being thrown downward, so that its ports are carried within the lower seat.

In the construction of the electrical arrangement the helix D is applied to a hollow spool with its axis coincident with that of the valve stem B, being mounted fixedly upon the arch C. The insulated wires *d d* terminate in binding posts *d'*, fixed to the spool, as shown, one or both of said posts being properly insulated from the spool, and both being adapted to receive the wires d^2 d^2, leading to and from the dynamo, and thereby bringing the helix D into the electric circuit of said dynamo. The valve-stem B is provided with the armature E, affixed thereto in proper position with reference to the helix to be raised by the latter when the force of the electric current is augmented therein. Said stem is also provided with the fixed collars or shoulders *b b'*, between which projects the branched end of the lever F, pivoted in the arch C at *f*. The outer end of said lever is connected with the fixed arm G by the contractile spring H, made adjustable as to its tension by the screw-threaded hook I and the thumb nut J.

By depressing the outer end of the lever F the stem B may be raised to bring the valve A into working position, as shown—that is to say, with the ports in the steam space between the seats. Whenever the speed of the engine becomes too great, the corresponding excessive force of the electric current, operating through the magnet D, will raise the valve and brings its ports partly within the upper seat, and thereby proportionately cut off the steam supply and lower the speed of the engine. Said stem is also shown prolonged through the upper end plate D' of the spool (which serves as a guide), and provided at its free extremity with a ring, B', by which also the valve may be raised to working position.

The lower shoulder, *b*, is exclusively used in the operation of the apparatus, being the only one upon which the lever bears by reason of the action of the spring in opposition to the attractive force exerted by the electro-magnet on the armature. The upper shoulder is used when in starting the machine it is desired to lift the valve by bearing down with the hand on the outer end of the lever. By placing the shoulders at a distance apart such as shown, the upper shoulder cannot normally rest on the lever so as to hold the valve up, it being observed that a valve of this class closes by reason of its weight automatically when the current is shut off or broken, and thereby prevents the engine from running away. The ring, when present at at the top end of the valve stem, may, however, be taken hold of and used as a means for conveniently lifting the valve-stem, in place of depressing the outer end of the lever.

In the use of the particular form of valve shown, or of other forms having similar action, should the current be broken the valve falls by its weight, or by its weight re-enforced by the spring H, and closes off the steam supply by carrying the ports of the cylindric valve into the lower seat.

Not only may the required uniformity of engine speed be obtained under varying work, as in other forms of governor, but in the use of the engine for the purpose of generating electricity for illumination the speed of the engine will be lessened or accelerated automatically when a number of lights are shut off or connected into the circuit. By means of the adjusting device applied to the spring H operating through the lever F, as described, a greater or less intensity in the lights may also be obtained, various forms of lamps requiring different intensities of current may be interchangeably used, and the number of lamps in the circuit may be varied from time to time, as may be desired, the adjustable spring being readily varied in its tension so as to control the valve in opposition to currents of differing power.

After the above description of the devices employed a detailed description of the operation is unnecessary. It is obvious that in the normal working of the machine the action of the magnet is to draw the valve cylinder upward, so that its ports will be regulated as to their area, and so as to control the amount of steam admitted to the engine in accordance with the force exerted by the magnet upon the armature *E*, the spring H operating through the lever F to depress the valve and open the ports whenever the force of the current is diminished. While the spring H, however, thus operates in conjunction with the magnetic current, it is plain that when said current ceases, as may happen from a variety of causes, or when a driving belt breaks or is thrown off its pulleys between the engine and the dynamo, the effect of said spring will be to instantly throw the cylindrical valve to its extreme lower position, carrying its ports within the lower seat so as to shut off steam. In other words, the spring H operates to open the ports when the electric current is in action through the magnet D; but in the absence of such current it serves to give the valve a throw of such extent as to close said ports and shut off steam. By using other means to close the valve in case the current is broken or a belt is thrown off, or by omitting all devices for this purpose, the adjustable spring H may be employed with other forms of valve than that here shown, with the same effect as to the variation of force in the magnet D under conditions above mentioned.

It is manifest that a solid core magnet may also be employed, if preferred, with only mechanical modifications of the construction shown.

It is further obvious that the governor described may be applied to control an engine through the medium of a variable cut-off by connecting the armature with the rod or other part operating the cut-off mechanism.

REIS'S ACOUSTICAL TELEPHONE.

[Prof. Houston, in his articles on the Philadelphia Exhibition, contributes the following on "The History of the Telephone," in the current number of the *Journal* of the Franklin Institute, in continuation of articles on the subject. This deals with, so to speak, a special phase of the question, and we therefore give it *in extenso.*]

The radical difference in principle that is claimed to exist between the transmitting instruments of Bell and those of Reis would naturally lead the unprejudiced student to expect to find marked differences in their mechanical structure. Such differences, however, do not exist. On the contrary, limiting the inquiry to a comparison of Reis's various forms of transmitters with those in general commercial use to-day, we will find resemblances of the most marked character, such resemblances establishing the fact we have already insisted on elsewhere, that Bell's contribution to the articulating telephone consisted in the production of a modification of an existing type of apparatus, and not the invention of a new genus.

Since the magneto-electric transmitter, such as described by Bell in his first patent, is in but comparatively limited use, we will exclude such apparatus from the present comparison.

Directing this comparison first to the mechanical structure, and secondly to the manner of operation of the various transmitters, it will be noticed that all transmitters of the type under consideration consist, so far as their mechanical structure is concerned, of three distincts parts, viz.:

1. The speaking tube, or mouth piece.
2. The diaphragm, or membrane.
3. The contact pieces, or apparatus for varying the contact.

In Fig. 10, which in common with Figs. 11, 12, 13, and 14 is taken from the work of Prof. S. P. Thompson on the "Telephone," only necessary parts are represented. The relative positions of the contacts and the diaphragm are, however, clearly shown in all.

In the upper row of sketches, from No. 1 to No. 5 inclusive, are shown various forms of transmitters, designed and constructed by Reis.

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No. 1 is a sketch of Reis's original human-ear transmitter. The platinum tipped end of the bent lever and its loose contact with the platinum point of the spring, together with their relations to the membranous diaphragm, are clearly shown.

No. 2 is a sketch showing the details of mechanical structure of the transmitting apparatus in Reis's bored-block transmitter, shown in Fig. 3. The platinum contact is attached to the centre of the diaphragm, and has resting against it a platinum point on the end of an adjustable spring. The battery connections and relations of parts to the diaphragm are as indicated.

No. 3 is a sketch of the mechanical structure of the Reis-Legat transmitter, shown in Fig. 5. The long, curved lever attached at one end to the centre of the diaphragm, and furnished with a platinum contact point that is pressed with a regulable pressure against a platinum point borne on the end of an elastic spring, is arranged in the manner shown.

No. 4 is a sketch of the Reis (Hockheimer) transmitter, shown more fully in Fig. 6. The platinum contact points are placed respectively on the middle of the diaphragm, and at the end of the regulable screw.

No. 5 is a sketch of Reis's cabinet form of transmitter, which is shown more fully in Fig. 7. In No. 5, however, the diaphragm is represented, for comparison, as vertical, instead of horizontal as when in use. The heavy vertical line, with the contact point near its lower end, represents the right-angled piece

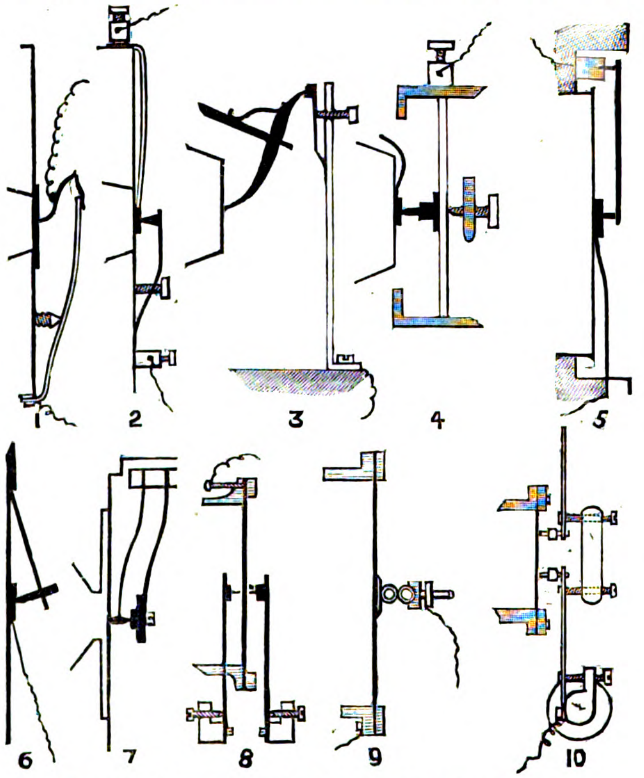

Fig. 10.—Comparison of Reis and Modern Transmitters.

of metal *h*, *g*, *i*, of Fig. 7. Its platinum contact piece rests with variable contact against the platinum point attached to the centre of the diaphragm.

It will be observed that in all of these forms of early Reis transmitters, except the last, means are provided for regulating the degree of contact or pressure between the contact pieces. In the last form, as will be readily understood, no such regulating device is required, since such adjustment is secured by the weight and inertia of the movable or upper contact piece.

No. 6 is a sketch of Berliner's transmitter. As we have not yet described these forms of transmitters, we will give more detailed drawings of the same. In Fig. 11 is shown the essential parts of the Berliner transmitter.

The contact piece *E* is securely attached to the centre of the diaphragm. A second contact piece, *k*, of the form shown, is hung from the arm *I*, which is loosely jointed at *N*, so as to permit the contact *k* to be passed against *E* by the weight of the swinging contact and its supporting arm. The electrical connections are as shown in the figure.

No. 7 is a sketch of the Blake transmitter. A more complete representation of the essential parts of this transmitter, omitting the induction coil, is shown in Fig. 12.

The Blake transmitter, as shown in the drawing, has its mouthpiece formed by a conical hole bored in a block of wood, with the diaphragm in front of the smaller end of the hole, as in Reis's bored-block transmitter. Both contact points are mounted on springs. The first contact consists of a small metallic spike, or pin, of any non-corrodible metal. This contact is thus referred to in the specification of the British patent, viz. :—

"It is desirable that it should be formed of, or plated with, some metal like platinum or nickel, which is not easily corroded. It may be attached directly to the diaphragm, but I prefer to support it independently, as shown, upon a light spring.

The other electrode is attached to a comparatively heavy weight, also supported by a spring, as shown. Of this electrode, the specification states :—"This weight may be of metal, which may serve directly as the electrode, but I have obtained better results by applying to it, at the point of contact with the other electrode, a piece of gas coke, or a hard-pressed block of carbon."

These contacts, with their supporting springs, and their positions with respect to the diaphragm and mouthpiece, are shown in sketch No. 7.

Nos. 8, 9, and 10 are various forms of transmitters devised by Edison, and described or referred to by us in the article on "Edison's Telephonic Inventions." In No. 8 the diaphragm has a contact point on each of its sides; No. 9 shows rubber hose replacing the elastic metallic springs ordinarily employed; No. 10 is an interrupting transmitter, with duplicated contacts.

Comparing the mechanical structure of the above apparatus with one another, it will be observed that Reis's No. 1 or original apparatus contains the three essential portions found in all the others, viz., the mouthpiece, the diaphragm, and the contact points, placed in an electric circuit, and so arranged as to cause their degree of contact, and consequently their electrical resistance, to vary with the movements of the diaphragm under the influence of the sound-waves.

No. 2 closely resembles the Blake transmitter in that one of the contacts is supported on an elastic spring. This is true of all of Reis's transmitters.

No. 4 still more closely resembles the Blake transmitter, as will be seen by the comparison of similar parts in each.

Fig. 11.—The Berliner Transmitter. Fig. 12.—The Blake Transmitter.

No. 5 resembles both the Beliner and the Blake transmitters, in the fact that the weight and inertia of the swinging contact are utilised for producing variations in the degree of contact on the movements of the diaphragm.

The resemblance of Nos. 8, 9, and 10 with the various forms of Reis transmitters will be evident on comparing similar parts.

In all the later forms of transmitters shown, from No. 6 to No. 10 inclusive, the three essential parts of the instrument, viz., the mouthpiece, the diaphragm, and the contact points, are not only present, but also sustain identically the same relations to one another as they do in the original Reis apparatus. Indeed, as is evident, they are in most cases almost exact imitations of Reis's apparatus. As far as their mechanical structure, then, is concerned, a careful comparison fails to reveal any difference between the original apparatus which Reis constructed for the purpose of transmitting articulate speech and the modified apparatus of later days. And yet it is claimed that the former apparati are not true articulating telephones, while the latter are.

Since the transmitting telephone operates mechanically on the electrical circuit, and transmits articulate speech solely in virtue of such mechanical action, if no mechanical differences in the structure of Reis's forms of apparatus can be pointed out by the advocates of Bell, then we submit that they must in fairness recognise Reis as the true inventor of the articulating telephone, and Bell as the modifier only. The description left by Reis of the construction of his various forms of transmitters is, beyond doubt, correct in all its details, and is such as would enable any skilled mechanic to go to work now and produce apparatus entirely similar to those described.

Let us now proceed to the second branch of the inquiry, viz., to the method of operation of the early Reis transmitters. After having given a full and correct description of the mechanical structure of his apparatus, Reis proceeds to explain the method of its operation. Whether such explanation is correct or not, does not appear to us to alter the facts of mechanical structure of the apparatus. If the description left by Reis is such a full and exact one as will enable a skilled mechanic to reproduce the apparatus, and if such reproduced apparatus, without any modification or

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change whatever, is capable of transmitting intelligible, articulate speech, then Reis invented the articulating telephone, and publicly disclosed his invention in such a full, clear, and exact manner as to enable others to make and use the same, and he therefore must be awarded priority of invention over Bell. Of course, in the preceding it is understood that along with a full description of the mechanical structure of the apparatus the inventor has added an explanation of the manner in which it was to be used. It was, of course, to be clearly stated that the transmitter was to transmit speech and the receiver was to receive it. Such a description is not wanting. The person is to talk or sing against the transmitting membrane, or into the speaking tube, or its vicinity, and the listener is to place his ear near or close to the receiving diaphragm. Nothing else is necessary. Let us, therefore, look into this in connection with Reis's explanation of the manner of operation of the different parts. That explanations as to the method of using the apparatus are not wanting the following quotation will show; for example, in Reis's article, entitled "On Telephony by the Galvanic Current," published in the *Jahresbericht* of the Physical Society of Frankfurt-am-Main for 1860-61, we find the following, viz.:—

"If now tones, or combinations of tones, are produced in the neighbourhood of the cube, so that waves of sufficient strength enter the opening *a*, they will set the membrane *b* in vibration. At the first condensation the hammer-shaped little wire *d* will be pushed back. At the succeeding rarefaction it cannot follow the return vibration of the membrane, and the current, going through the little sprip (of platinum), remains interrupted so long or until the membrane, driven by a new condensation, presses the little strip (coming from *p*) against *d* once more. In this way each sound-wave effects an opening and a closing of the current.

"Tunes and sounds of any kind are only brought to our conception by the condensations and rarefactions of air or any other medium in which we may find ourselves. By every condensation the tympanum of our ear is pressed inwards; by every rarefaction it is pressed outward, and thus the tympanum performs oscillations like a pendulum. The smaller or greater number of the oscillations made in a second gives us, by help of the small bones in our ear and the auditory nerve, the idea of a higher or lower tone."

* * * * *

"The apparatus consists of two separate parts: one for the singing station *A*, and the other for the hearing station B." See Fig. 12.

"The apparatus *A*, a square box of wood, the cover of which shows the membrane *c*, on the outside, under glass. In the middle of the latter is fixed a small platina plate, to which a flattened copper wire is soldered on purpose to conduct the galvanic current. Within the circle you will further remark two screws. One of them is terminated by a little pit in which you put a little drop of quicksilver, the other is pointed. The angle which you find lying on the membrane is to be placed according to the letters with the little whole (hole) *a* on the point *a*, the little platina foot *b* into the quicksilver screw, the other platina foot will then come on the platina plate in the middle of the membrane.

"The galvanic current coming from the battery (which I compose generally of three or four good elements) is introduced at the conducting screw near *b*, wherefrom it proceeds to the quicksilver, the movable angle, the platina plate, and the complementary telegraph to the conducting screw *s*. From here it goes through the conductor to the other station *B*, and from there it returns to the battery.

"The apparatus *B*, a sonorous box, on the cover of which is placed the wire-spiral with the steel axis, which will be magnetic

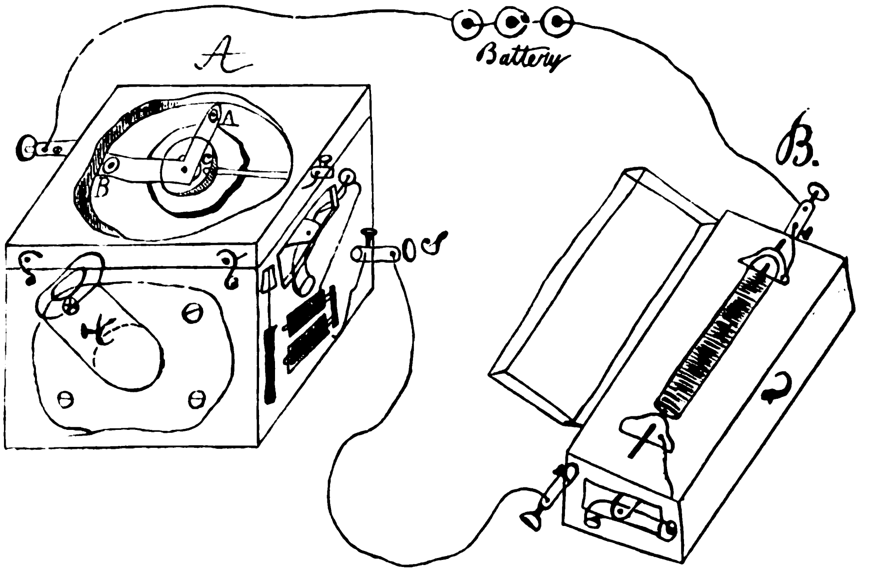

Fig. 13.—Pen and Ink Sketch of Telephone Accompanying Reis's Letter to Ladd.

"But, at every closing of the circuit, the atoms of the iron needle, lying in the distant spiral, are pushed asunder from one another. (Müller-Pouillet, *Lehrbuch der Physik*, see page 304, of Vol. II., fifth edition.) At the interruption of the current the atoms again attempt to regain their position of equilibrium. If this happens, then, in consequence of the action and reaction of elasticity and traction, they make a certain number of vibrations, and yield the longitudinal tone of the needle. It happens thus when the interruptions and restorations of the current are effected relatively slowly. But if these actions follow one another more rapidly than the oscillations due to the elasticity of the iron core, then the atoms cannot travel their entire paths. The paths travelled over become shorter the more rapidly the interruptions occur, and in proportion to their frequency. The iron needle emits no longer its longitudinal tone, but a tone whose pitch corresponds to the number of interruptions (in a given time). But this is saying nothing less than that the needle reproduces the tone, which was imparted to the interrupting apparatus."

Omitting the explanations as to the theory of its operations, the above clearly states the manner in which Reis intended his apparatus to be used. The receiving instrument being placed in the circuit of the transmitter and a voltaic battery, as elsewhere directed, one talks or sings into the mouthpiece of the transmitting apparatus, while another listens at the receiving apparatus. All this precisely as in the case of the so-called modern invention.

So, too, in a letter written in English by Reis, in July, 1863, to Mr. Ladd, of London, which follows.

when the current goes through the spiral. A second little box is fixed on the first one, and laid down on the steel axis to increase the intensity of the reproduced sounds. On the small side of the lower box you will find the correspondent part of the complementary telegraph. [The device here alluded to was a small electromagnetic signalling device, corresponding to the call-bell.]

"If a person sing at the station *A*, in the tube *x*, the vibrations of air will pass into the box and move the membrane above; thereby the platina foot *c* of the movable angle will be lifted up, and will thus open the stream at every condensation of air in the box. The stream will be re-established at every rarefaction. For this manner the steel axis at station *B* will be magnetic once for every full vibration, and as magnetism never enters nor leaves a metal without disturbing the equilibrium of the atoms, the steel axis at station *B*, must repeat the vibrations at station *A*, and thus reproduce the sounds which caused them.

"*Any* (the italics are Reis's) sound will be reproduced, if strong enough to set the membrane in motion."

Here the description of the mechanical structure of the apparatus, the disposition of its various parts, and the manner in which they are intended to be used, are far more explicit than in many patent specifications, and in particular more explicit than the directions to be found in the specification of Bell's so-called telephone patent of 1876.

Besides the above, we quote Prof. Thompson's translation of a prospectus that was issued with the Reis apparatus, sold by Albert, of Frankfort.

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TELEPHON.

"Each apparatus consists, as is seen from the above illustration, of two parts, the telephone proper *A* (Fig. 14)*, and the reproduction apparatus (receiver) *C*. These two parts are placed at such a distance from each other that singing, or the tones of a musical instrument, can be heard from one station to the other in no way except through the apparatus itself.

"Both parts are connected with each other, and with the battery *B*, like ordinary telegraphs. The battery must be capable of effecting the attraction of the armature of the electro-magnet placed at the side of station *A* (3—six-inch Bunsen's elements suffice for several hundred feet distance).

"The galvanic current goes then from *B* to the screw *d*, thence through the copper strip to the little platinum plate at the middle of the membrane, then through the foot *c* of the angular piece to the screw *b*, in whose little concavity a drop of quicksilver is put. From here the current then goes through the little telegraph apparatus *e*, *f*, then to the key of station *C*, and through the spiral past *i*, back to *B*.

"If now sufficiently strong tones are produced before the sound-aperture *S*, the membrane and the angle-shaped little hammer lying upon it are set in motion by the vibrations; the circuit will be once opened and again closed for each full vibration, and thereby there will be produced in the iron wire of the spiral at station *C* the same number of vibrations which there are perceived as a tone or combination of tones (chord). By imposing the little upper case firmly upon the axis of the spiral the tones at *C* are greatly strengthened.

"Besides the human voice (according to my experience) there also can be reproduced the tones of good organ pipes from *F*—*c*, and those of a piano."

A careful consideration of the preceding quotations will render it clear that no objections can be found with the descriptions that Reis gives of the mechanical structure of his apparatus, nor of the manner in which it is to be used in the transmission and reproduction of *all kinds of sounds*, including, as is repeatedly claimed by Reis, articulate speech. Nor, indeed, are we aware that any such objections have been urged, unless it be the very remarkable one that Reis never intended his apparatus for the transmission of speech, but only for the transmission of musical sounds—a statement of marvellous assurance, in view of the very explicit statement of Reis that his apparatus was designed to transmit speech, and that such speech was actually transmitted. The argument made by the advocates of Bell against the claims made for Reis as to the invention of the telephone refers almost entirely to the theory of its actions as advanced by Reis in the preceding quotations. It is insisted that the makes and breaks referred to by Reis were absolute and complete, and were followed by absolute and complete cessations of the electrical current in the circuit of the transmitting and receiving instruments. That such currents cannot by any possibility act to reproduce articulate speech, and since, as they claim, Reis intended to describe such makes and breaks, his apparatus never could have transmitted or reproduced such speech.

It never seems to have occurred to such objectors that if even the smallest possibility of misunderstanding existed as to Reis's interpretation of the words "make" and "break," a spirit of but ordinary fairness would have led to the inquiry as to whether the original Reis apparatus would transmit articulate speech as he and others claimed, in which case it would appear that either,

1. The assumption made by them that makes and breaks, complete and absolute, cannot transmit articulate speech is untrue; or,
2. That Reis did not intend to convey the same meaning by his use of the words makes and breaks as they assumed him to do, but that the makes and breaks were the variations in the electrical resistance of the circuit that exactly corresponded to the variations in the movements of the transmitting diaphragm when acted on by the impinging sound waves, or, as Reis says in the *Jahresbericht* article, "to set up vibrations whose curves are like those of any given tone or combination of tones;" or,
3. That, although the description given by Reis of the manner in which his apparatus actually operated was inaccurate, yet the mechanical structure of the apparatus, the relative proportions of its parts, and the method in accordance with which they were intended to be used, were such as would enable them to do all that their inventor claimed.

That very grave doubts fairly exist as to the meaning Reis intended to be given to his use of the words "make" and "break" there can be no question. The mechanical structure of the apparatus itself, and the masterly manner in which Reis, in the *Jahresbericht* article, considers the nature of the curves in the case of compound sounds, prove beyond reasonable doubt that he clearly understood the principles according to which the telephone transmitter varied the intensity of an electrical current, so as to permit it to reproduce in the receiver the sounds made at the transmitter.

The matter will, perhaps, be made clearer by an examination of the Reis and other transmitters, shown in Fig. 10, while discussing the method in which they act while in actual operation.

(To be continued.)

* This figure practically represents the perspective view of Fig. 13.

THE NEW SUBMARINE CABLE FOR THE PERSIAN GULF.

Letters have been received from Suez descriptive of the severe gale encountered by the "Dacia" in the Bay of Biscay from the 8th till the 10th of October on her voyage out to the Persian Gulf. She sailed from the Thames on the 6th, followed two days later by the "International," and besides her officers and crew had on board the chief of the expedition, Colonel Bateman-Champain, R.E., Director-in Chief of the Indo-European Telegraph, for the thorough efficiency of which department as a means of communication between England and the East the country is chiefly indebted to Colonel Bateman-Champain himself. There were also on board the "Dacia" Sir Henry Mance, C.I.E., electrician of the Persian Gulf cables; Dr. Denis Scully, of the Persian Telegraph staff; and a few passengers accompanying the expedition, among whom were Colonel G. A. Leach, R.E., Land Commissioner of England.

The weather was stormy when the "Dacia" sailed, and the friends who assembled to wish God speed to the expedition could not but think of the unlucky history of the last Persian Gulf cable, laid in 1868, after having been abandoned and salvaged in the "Calcutta" during a terrific gale in the English Channel, and after the P. and O. steamer "Carnatic," with Colonel Bateman-Champain on board on his way to superintend the laying of the cable, had been wrecked, and upwards of 60 of her passengers and crew had perished in the Red Sea.

The following extracts from a private letter from Colonel Bateman-Champain to a friend in England show how near the forebodings about the previous expedition were to being realised:—

"Steamship 'Dacia'—When we woke up this morning (8th October), things were looking gloomy. A strong wind was blowing straight in our teeth as we steered for Ushant, and we hardly made any progress. Of course, too, it rained hard at intervals, and was cold, while the ladies and landsmen were showing decided symptoms of sea-sickness. The ship, however, was amazingly steady, considering the sea was pretty rough, and all I felt sulky about was our slow speed. The wind kept on rising and, of course, the sea likewise. In the evening (8th) a regular gale came on, and all we could do was to lie to, head to wind, and ride it out. We pitched and rolled a good deal, and the sea began to wash over our decks, so that it was rather difficult to get to and from my cabin. Once I got a green sea right over me, and had to change every rag. Altogether the 9th was a miserable day, and there was no sign of the tempest abating. That night we had almost a hurricane. A wave carried away one of my windows, after I had turned in, and set my cabin awash, but I could not join the others for fear of being swept overboard on the journey aft. About midnight one of our boats was washed away, to our immense disgust, because if picked up with 'Dacia' plainly painted on her you poor people would imagine the worst. Friday night was the worst, but Saturday was bad enough, and by this time the sea was terrible. It broke through the skylight into the saloon, and we had to batten down all the hatches and sit through the day by lamplight. To go on deck was hardly possible, as it was continually under water, but I persevered in sleeping in my deck cabin, the water splashing about as I lay in my berth. At 6 p.m. the skipper, Captain Barker, thought he saw some improvement, and determined to stand on our course, and then didn't we roll! We nearly lost another boat, and had a miraculous escape of a collision. Just after dark a strange steamer ran across our bows, scarcely 100 yards away, and one half minute would have settled us both. Moore (one of our cable hands), twenty years at sea, vows he never before was so near his grave; but he is rather a croaker. Still, it wasn't nice, as no boat could have lived a minute in such a storm. Sunday, the 11th, was much better, the sea tremendously rough, but we felt that we were doing something instead of helplessly lying to and waiting for a change which wouldn't come. We had frequent squalls, and a strong wind on our beam, but got away, and began to think of drying ourselves. Monday morning saw us out of the Bay. Tuesday was lovely, and to-day (Wednesday, 14th) it is just perfect. The ship is cleaned up, and all is peace and joy. What a change! I never met with better shipmates. The captain and officers are excellent, the crew are clippers, and the cooks and stewards are as obliging and smart as men can be. The kitchen is as clean as a dairy, and the food excellent. In short, we are in clover, and I trust that now our troubles are over. We signalled yesterday from Lisbon to relieve anxiety. October 23, 4 p.m. Arrived all jolly at Port Said. 25th, in the Canal, 3:15. Here we are stopped to let a P. and O. pass. 9 p.m.—Here still. Another little misadventure has occurred, which might have proved disastrous. You must know that in the canal there is not width for two ships to pass, but every seven or eight miles are stopping places, where the outward or homeward bound vessel, as the case may be, ties up to the bank to let the oppositely directed vessel go by. We had first to tie up, and when the 'Verona' and 'Vectis' had gone by they had to do the same to make room for the 'Tangier,' a great big heavy ship which was following us. As another Dutch ship was coming north from Suez neither we nor the 'Tangier' could go ahead, and it was the 'Tangier's' business to make fast between the 'Verona' and us till the 'Dutchman' passed, and then we could all start again. I was standing on our quarter-deck watching the 'Tangier' steering straight at us, and I observed to Dr. Scully, 'if that Tomnoddy doesn't go astern

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he will be into us.' On he came, slowly but surely. We could not move, being securely made fast to posts, so all we could do was to helplessly watch the collision. The 'Tangier' ploughed on, neither going astern nor steering clear, and scraunch she went through our best little boat, grinding it to smithereens, then scraunch through our bulwarks, and had she been moving a bit faster she must have cut us in two. Of course, we personally were safe enough if no mast or gear fell on our heads; but fancy all this cable and paraphernalia being swamped, and having either a month's delay or the whole job to do again. Luckily no very serious damage has been done. We shall botch up the ship's side and start again to-morrow morning. The 'Tangier's' people will have a nice little bill to pay, as the fault was entirely due to their pilot. The truth seems to be that these pilots, all French and Italian, lose their heads at the least hitch, get excited and helpless, and come to grief. The 'Tangier' man should take to plumbing and glazing, for a more inexcusable accident could not be imagined. The 'Tangier' hit the 'Dacia,' and we could not get apart for more than an hour"—*The Times.*

LEGAL.

In the Chancery Division of the High Court of Justice, before Mr. Justice Kay, the case of Cooper *v.* Slatter came on for hearing yesterday.

It was a dispute between two electrical engineers, who, while arranging the terms of a partnership, obtained two valuable contracts—one in connection with the Rosario Railway, and the other from Messrs. Bailey, Hawkins, and Co. On the eve of signing the necessary documents to complete the partnership differences arose, and they separated; whereupon Mr. Slatter claimed to be entitled to execute the contracts. Mr. Cooper contended that the defendant was not competent to complete them, and urged that the second contract named was obtained by the plaintiff on the introduction of a member of the firm of Sir Charles Fox and Co.

The JUDGE decided to appoint Mr. Slatter as receiver and manager, to carry out the contracts until the trial of the action, the defendant giving the necessary security.

COMPANIES' MEETINGS & REPORTS.

Eastern Extension, Australasia, and China Telegraph Company (Limited).

The twenty-fourth ordinary general meeting of this Company was held on Tuesday, the 10th inst., at the City Terminus Hotel, Cannon-street, London, under the presidency of John Pender, Esq., M.P.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the minutes of the last meeting, which were approved by the present meeting, and signed by the Chairman. The report of the Directors, which has already appeared in *The Electrician*, was taken as read.

The CHAIRMAN: Gentlemen, you have in the report a very full account of the Company's working during the last six months. However, I shall, as usual, make some remarks upon the report which is in your hands. The gross receipts for the half year have amounted to £259,476, against £237,672 for the corresponding period of 1884, showing an increase of £21,804. The working expenses for the same period have been £74,418, against £66,658 for the corresponding half of 1884, showing an increase of £7,760, which is more than accounted for by the loss in connection with that unfortunate vessel the steamship "Magneta." That vessel, as stated in the last report, was fully insured; but the Company, in accordance with its usual practice, underwrote half the value of the cable on board, and the loss upon this, together with the payments to the relatives of the crew and the expenses of the ship's fittings and those incurred during the voyage, amounted to nearly £10,000, as shown in the accounts. This, as you will see, we have charged against the revenue of the past half year. The net revenue for the half year was £140,358, against for the corresponding period of 1884 £127,415, showing an increase of £12,943. The usual dividend at the rate of 5 per cent. per annum, together with a bonus of 2s. per share, making a total payment of 3½ per cent., has been paid for the last half year, and the balance carried forward, after charging a further sum of £20,000 towards the cost of renewing the Singapore-Saigon and the Penang-Rangoon cables, is £32,858. In regard to the Singapore-Saigon and the Penang-Rangoon cables, it was anticipated that the whole of the operation would be finished before the 30th of June, so that the cost would be shown in the accounts under review. But it was not found convenient to pick up the whole of the old cable till after the close of the half-year and consequently the final figures will be given in the accounts of the current six months. No fresh renewal has been carried out in the half year, but your Directors have decided to pick up the cable—400 knots in length, laid in 1870 between Singapore and Penang, which has for some years past, and especially of late, been much interrupted, necessitating frequent and costly repairs—and put down a new brass-ribboned cable in its place. Although we have to incur the cost of this renewal of the cable, we expect at the same time to get rid of a very considerable annual outlay on repairs. Moreover, the cable we pick up is not lost. We re-serve it, and put it into stock at Singapore, using it as occasion requires. For instance, last year with the cable we had at our command we were able to meet the requirements of H.M. Government indirectly through the Telegraph Construction Company, by laying a cable to Port Hamilton at a time when the Government urgently required the connection. Consequently, while it appears that we are spending a considerable sum of money in relaying these cables, we have generally found that in the end there has been no loss. I may mention that the Port Hamilton cable has since been broken, but we expect it will be in working order shortly. Since I addressed you last we have had a new steamer built, called the "Recorder," to replace the one lost. We have never heard any account whatever of the "Magneta." It is one of the most remarkable things that have ever occurred—that a vessel so well found in every way should have so entirely disappeared. I may mention that the recorder is the name of the valuable instrument invented by Sir William Thomson, one of the greatest electricians of the age, and, probably as an instrument, it is the nearest approach to human action that has been yet introduced into electric telegraphy. We thought it was only a proper compliment to pay to the great electrician that we should name this ship after his most important and valuable instrument. The ship is now lying in the Thames, and probably a more complete ship has never been fitted out for the purpose. She will proceed shortly to Singapore, and I hope will prove of valuable service to the Company. But, as I have often mentioned, the less our ships are employed the better for the Company's interests. I think these are the chief points connected with the working of the Company. But there is another question which I daresay many of you will be interested to hear something about—namely, as to what occurred at the Telegraph Conference at Berlin the other day. A great deal appeared in the newspapers in regard to that Conference. I may first of all tell you that the Submarine Companies at these Conferences have no votes, but are allowed to speak, and we must, therefore, through moral suasion, influence the different delegates representing the various States. Unless, therefore, our arguments are based upon justice, you may be sure that we should not carry our point. The President of the Conference, Dr. von Stephan, whose great object was to get the rates reduced as much as possible, recognised the value and importance of submarine cables, which, having their origin in England, have given to the States of Europe the same advantages which England derives; and in these days, when the European States are looking all round for new countries to colonise, you can well understand that they take a lively interest in submarine telegraphy, and that they try, as far as their influence and power go, to reduce our rates as much as possible. We, therefore, as a company, or a combination of companies, had practically to fight the European States. But when I tell you that the companies own 98,450 miles of submarine cable, costing £34,460,000, while the Governments own only 7,300 miles of cable, costing £1,460,000, and that the value of the companies' cables exceeds that of the whole of the land lines belonging to all the States of Europe, you will understand that our position at the Conference was a very important one, and one which we had to defend with all the intelligence and influence we possessed. There was one very important point that we dealt with at the Conference, and that was how far we could reduce our rates. The Eastern Extension Company have for some time been considering the necessity of reducing the rates to Australia. Why? Because we found that there was a considerable amount of vitality in the Australian traffic, and by a reduction we felt we could increase our receipts in the course of a few years to such an extent that we should recoup the first loss. But we felt that India, which is a party to this system, should take a share in the reduction. I therefore announced, on the part of the companies, that I was quite prepared to make a reduction provided that India and South Australia accepted their proportions. The South Australian Government at once agreed, and I may mention that their delegate telegraphed to Australia, and so promptly was his message attended to that I think in ten hours we had the reply that they were prepared to reduce their proportion. The Indian Government, on the other hand, replied that their exchequer could not afford it, and declined. I was then urged very strongly to give the reduction unconditionally, but I refused, because I had the Australian colonies as a lever to act upon the Indian Government, and I was not going to give up the opportunity which I had been labouring for for the last two years to get the Indian Government to reduce her high transit rate across India. I will give you a little idea in regard to what I call one of the hardships which the Australian people have to submit to from the charges of the Indian Government. If we had the same arrangement with the Indian Government for the transmission of our international messages across India that we have with the English Government—that is, having a special wire, and paying so much for it—the difference would be that we would pay the Indian Government £3,500 a year, whereas now we pay £40,000 a year. If we were to get that reduction it would enable us to give the Australian colonies a reduction of 2s., in addition to the 2s. we were prepared to give them. That is the position we are in at the present time. We are endeavouring to bring pressure on the Indian Government, and are being supported by the Australian Agents-General in the object we have in view, and I am hopeful, before I meet you again, that we shall have carried our point, and thus largely benefit Australia, which is entitled to consideration, without seriously affecting the receipts of the Company. The estimated loss by the reduction, if carried out, both to India and China will not exceed £40,000 a year, and I believe we shall soon be able to recoup that. Meantime, you will, I believe, receive your dividends from time to time as you have hitherto done unless some unforseen circumstances arise. I have now given you at some length an outline of what was done at the Telegraph Conference. The next Conference will meet in five years' time, and I hope, until then, we shall be comparatively at rest. But I say this publicly, that we must always bear in mind that we have to pay dividends, and that we ought rather to be moving upwards than downwards. We shall, however, endeavour as far as possible, when we see a decided growth in the traffic, to make such reduc-

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tions as we are warranted in making without injuring the Company's interests. We have to pay dividends, but Governments have not. Many of the land telegraph systems of Europe do not pay, and consequently they have to draw upon their exchequers. But we cannot do that. I think with the position we occupy now we give a service perhaps second to none, and there is not much possibility of any competition arising. Competition may of course arise, but it cannot do the work cheaper or so well as we are doing it. I think I have now touched upon all points of interest to you. I may, however, mention one other matter, and I think I may do so good-humouredly, namely, that we have a right to complain of want of courtesy upon the part of some of the Press. For some years we were unable to induce the German Government to make a reduction in the Press rates for Australia, although quarter rates have been given over the Extension Company's lines for a long time past, and it was the wish of my colleagues and myself that the reduction should apply to the whole system between England and Australia; but we were never able to get permission to carry it out. At the very first interview I had with Dr. von Stephan, when he was proposing certain reductions, I said: Sir, for years you have stopped progress in telegraphs; but you are now making a new departure. Your desire is to reduce rates and increase traffic. Now, the first thing I ask you to do in the interest of the Press is to reduce to quarter rates. He could not get out of it, gentlemen, and he admitted it. While we have been blamed by the Press for refusing to make large concessions, I have never heard one compliment paid to us for the enormous advantages which we give to the Press. When the Press of Australia were hitting us very hard because we would not give up 1s. 6d. as India would not give up 3d., they might have admitted that they were getting this concession; but they did not do so, and I complain that we receive no support from them. I hope the Press will take these few remarks good humouredly, and that they will help us when we are entitled to help. He concluded by moving the adoption of the report and accounts.

The Marquis of TWEEDDALE seconded the motion.

Mr. JOHN NEWTON observed that about a couple of years ago the Chairman led them to expect a great accession of telegraphic business through the opening up of China, and he wished to know if there was any greater prospect of the development of telegraph business from that cause. In China they did not appear to talk so much about depression of trade as we did, and he was rather disposed to think that there was not so much reason for it in the far East.

The CHAIRMAN: Probably there is no country at the present time that wants more money than China does. If the Chinese give contracts to European contractors for making railways—and they are moving in that direction—it will be an enormous benefit to our telegraph system. They are, as I have said, moving in that direction, and we only hope that they will move quickly. He then put the resolution, which was carried unanimously.

A SHAREHOLDER: In the event of the Indian Government not agreeing to your proposal you will, I suppose, have to carry out your reduction as regards Australia?

Mr. GRIFFITHS: No; they are willing to give the reduction to Australia when India makes the concession referred to by the Chairman.

The CHAIRMAN: This is not the first time this question has been put to me, and I may as well reply to it. Since I returned from Berlin I have had an interview with the Australian Agents-General, and they put the very question to me which the honourable shareholder has just asked. I said to them: "If I were to say to you, 'Yes, we will give you these reduced tariffs,' you would put your hands in your pockets and not try to get anything for us. You have a prospect of getting an additional 2s. to what we are prepared to give you, if you get this concession from India, and I wish you to work for it. I am not going to throw away this lever till I think there is some action on the part of those who will so greatly benefit by the reductions we propose." That was my reply.

Mr. HEIRON thought it was the duty of the meeting to pass a vote of thanks to the Chairman for his clear and able speech in making the statement which he had just addressed to the shareholders of the Company, which was one of the most important telegraph companies in the kingdom. It afforded him very great pleasure in proposing a vote of thanks to the other Directors as well for their able management of the Company's affairs.

Mr. GRIFFITHS, in seconding the motion, said that no one could have listened to the Chairman's speech without being convinced of the ability brought to bear on the management of the Company's business. They were prospering, and there was no doubt that their prosperity was to a great extent attributable to the able conduct of their affairs.

The motion having been carried unanimously,

The CHAIRMAN said: Gentlemen, I am much obliged to you for the compliment you have paid to my co-Directors and myself. You may rest assured that our interests are your interests, and that you stand in a better position to-day than you did before we went to the Conference.

The proceedings then terminated.

The West India and Panama Telegraph Company (Limited).

Report of the Directors for the six months ended June 30 last, to be presented at the seventeenth ordinary general meeting of members, at the Cannon-street Hotel, on Wednesday, the 18th inst., at three o'clock:—

The amount to credit of revenue is £51,012. 1s. 7d., and the expenses have been £28,038. 11s. 8d., leaving a balance of £22,973. 9s. 11d., which, with the balance of £500. 2s. 10d., brought from last account, makes a total of £23,473. 12s. 9d. Of this sum the Directors have placed £6,000 to reserve, leaving an available balance of £17,473. 12s. 9d., with which it is proposed to deal as follows:—

	£	s.	d.
Payment of 9s. per share on account of arrears of dividend on the First Preference shares	£15,553	7	0
Balance to current half-year's account..............	1,920	5	9
	£17,473	12	9

The traffic receipts for the half year show an increase of £2,459. 1s. 2d. over those of the corresponding period of 1884, attributable to a lesser number of interruptions, and to the disturbances in Colon during the month of April last. The ss. "Duchess of Marlborough," which came home in July to be refitted and supplied with a new boiler, has been thoroughly overhauled in accordance with Lloyd's requirements, and has since returned to St. Thomas with 77 knots of new deep-sea cable, manufactured by W. T. Henley's Telegraph Works Company (Limited). In order to proceed with the repairs of the original Jamaica-Santiago de Cuba section referred to in the last report, and to meet any other contingencies, a contract has been entered into with Siemens Brothers and Co. (Limited), for the manufacture of 250 knots of deep-sea cable, and the Company's ss. "Grappler" is on her way home for the purpose of carrying out this cable. Several sections of the Company's line were interrupted during the period under report, but they are now in good working order.

Business Notices.—Mr. H. C. Harold, of 30 and 31, St. Swithin's-lane, E.C., has, we are informed, been appointed the sole agent for the sale of the electric light carbons, battery plates, and electrodes manufactured at the works of the Liepmann Carbon Company (Limited), Millwall, E.—Messrs. Paterson and Cooper inform us that after the 16th inst. their offices and show rooms will be removed to their works at Pownall-road, Dalston, owing to the termination of their lease at Little Britain. The Dalston premises are situated close to Haggerston Station, some ten minutes by rail from Broad-street.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Nov. 11.		Business Done Week Ending Nov. 11. Highest.	Lowest.
Anglo-American	32½,	33½	33¼	31½
Do. Preferred	54½,	55½	55¾	53½
Do. Deferred	9,	9½	9 7-16	8½
Brazilian Submarine	11¼,	11½	11 9-16	11⅜
Cuba	12¼,	12¾	12½	—
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	1½	—
Do. Preference	11½	12	—	—
Direct United States Cable	9⅜,	9⅝	9⅝	9½
Eastern Telegraph	11½,	11¾	11¾	11⅝
Do. 6 per Cent. Preference	13½,	14	14	13⅝
Do. 5 per Cent. Debentures, 1899	105,	108	107½	—
Eastern Extension	12¾,	13	13	12¾
German Union	9½,	10	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 3-16	6¾
Do. Preference	13⅛,	13⅜	13⅜	13⅛
Great Northern	13⅞,	14⅛	14	13⅞
Indo-European	31½,	32½	32¼	—x.d.
Reuter's	7¼,	7¾	7½	—
Submarine	205,	215	212	208
West India and Panama	⅞,	1	⅞	—
Do. 1st Preference	9,	9½	9⅜	9 5-16
Western Brazilian	5⅝,	5⅞	—	—
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—x.d.

TELEPHONES.

Consolid. Telephone and Maintenance	⅞,	1	15-16	—
Oriental	3-16,	5-16	—	—
United Telephone	12½,	13	12 15-16	12½

ELECTRIC LIGHT.

Anglo-American Brush Light (£3 paid)	2¼,	2¾	2⅜	2
Do. (fully paid)	4,	4½	4¼	3¾
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	⅛,	⅜	⅝	—
Maxim-Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	36,	37	36¾	36½
India Rubber, Gutta Percha, and Telegraph Works	23½,	24½	24	23⅝

TRAFFIC RECEIPTS FOR OCTOBER, 1885.

Companies.	Oct., 1885.	Oct., 1884.	Increase.	Decrease.
Cuba Submarine	2,100	2,230	—	130
Direct Spanish Telegraph	1,748	1,816	—	63
Eastern Telegraph	56,994	53,865	3,129	—
Eastern Extension	43,986	41,357	2,629	—
Great Northern	24,400	—	—	—
West Coast of America	3,475	—	—	—

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NOTES.

THE WAR WITH BURMAH.—A telegram from Thayetmyo, dated November 18, says that the telegraph was found working to Mandalay.

TELEGRAMS FOR BULGARIA, &c.—It is notified that telegrams for Servia, Bulgaria, and Roumelia can now be accepted only at sender's risk.

CENTRAL ASIAN TELEGRAPHS.—A telegram dated St. Petersburg, November 19, announces the completion of the telegraph line between Merv and Penjdeh on that day.

INDIAN AND COLONIAL EXHIBITION.—H.R.H. the Prince of Wales, President of this Exhibition, has approved of the *Journal* of the Society of Arts becoming the official organ of the Exhibition.

THE EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY. This company publish the numbers of 1,203 five per cent. mortgage debentures of £100 each, which have been drawn for payment at par on 1st January, 1886.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th November are £1,827, as compared with £2,170 in the corresponding period of 1884.

SALES OF PLANT AND APPARATUS.—Particulars will be found in our advertisement columns of two interesting sales of valuable mechanical plant and electrical apparatus, to be conducted next month by Messrs. Wheatley Kirk, Price and Goulty.

A VACANT CHAIR.—The position of Professor of Experimental Physics in the University of Sydney, recently occupied by Prof. John Smith, C.M.G., M.D., LL.D., &c., is vacant in consequence of his death. The salary is £900 per annum and one-half of the fees.

THE ELECTRIC LIGHT IN SWEDEN.—Strehleuert and Co., Sodertelge, have established the first manufactory in Sweden for electric lamps. It is constructed after the American pattern, and is managed by electricians, &c., who have had several years' experience in the United States.

ELECTRIC SIGNALLING FROM BALLOONS.—The current number of *Electricité* contains an account of some experiments in electric signalling from balloons, carried out by MM. Mangin and Royer. The experiments are identical with those of Mr. E. Bruce, recently described in our columns.

THE CREIL EXPERIMENTS.—Criticising the recent experiments of M. Marcel Deprez, M. Hospitalier says that the more he examines the results submitted to the Academiè des Sciences on the 26th ultimo, the less he is able to understand the enthusiasm which they have called forth. We are of precisely M. Hospitalier's opinion.

THE TELEGRAPH BATTALION.—A committee is now considering the question of the employment of pensioners and reserve and discharged men of the Telegraph Battalion in the service of the General Post Office. Should their recommendations be carried into effect, an opening will be given to those men who, on leaving the service, are considered eligible.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—A meeting of this society will be held at the Institution of Civil Engineers, 25, Great George-street, S.W., on Thursday, Nov. 28, 1885, when the following paper will be read, "On the Necessity for a National Standardising Laboratory for Electrical Instruments," by J. A. Fleming, M.A., D.Sc., member.

ANOTHER EARTHQUAKE IN CASHMERE.—A Reuter's telegram, dated Bombay, November 16, says that the inhabitants of Srinagar, Cashmere, have again been thrown into a state of alarm and consternation at the recurrence of earthquake shocks there. The first shock, a severe one, was felt on the night of the 15th, and this has been followed by a constant series of slighter ones.

THE PERSIAN GULF CABLE.—We are informed that the steamers "Dacia" and "International," belonging to the India Rubber, Gutta Percha, and Telegraph Works Company, were at Jask (Persian Gulf) on the 14th inst., and the laying of the new Persian Gulf cable commenced on the following day, under the direction of Colonel Bateman-Champain, R.E., assisted by Sir Henry Mance, C.I.E.

THE ELECTRIC LOCOMOTIVE AND POWER COMPANY.—On Tuesday last we were invited by this Company to witness a trial of their electric tram engine, which was announced to take place at the North Metropolitan Tramway Company's depôt at Stratford, E., on the same day. As on other occasions, however, when sufficient notice has not been given us, we were compelled to decline the invitation.

THE ELECTRIC LIGHT IN DENMARK.—The first establishment lighted throughout by the electric light in Denmark is the beet-sugar manufactory at Nykjobing, on the island of Falster. The number of lamps is 200, of 16 candle-power each. They are manufactured at Mr. Förgenser's establishment in Copenhagen. The sugar manufactory is only in operation for the winter quarter, but the lamps will be needed from 14 to 16 hours out of the 24.

THE BECHUANALAND TELEGRAPHISTS.—Major Jelf arrived in England from Cape Town on the 5th inst., and a contemporary is informed that the section of the Telegraph Battalion from Bechuanaland will arrive home towards the end of the present month. The following men of the 2nd Division have been nominated as military telegraphers to remain in Bechuanaland with the police force:—Lance-Corporal Jones, Sappers Hepworth, Craddock, Lewis, Ancell, and Tutin.

BLEACHING BY ELECTRICITY.—Cotton manufacturers in St. Petersburg are said to be becoming much interested in the application of electricity for the purpose of bleaching cotton and flax fibres as well as tissues. The material is steeped in water, which is then decomposed by electricity, the oxygen which is thus set free at once acting on the fibres. This process, which has already been described in our columns, has been found to occupy very considerably less time than the ordinary one.

PROPOSED TELEPHONE FOR BATH.—At a meeting of the surveying committee held recently, prior to the election of mayor, the clerk read an application from the Western Counties and South Wales Telephone Company, stating their intention, if sanctioned by the Corporation, to open their overground wire exchange system in Bath and to connect Bath with Bristol by trunk wires. The question was deferred to the next meeting, the clerk to write and ask for a plan, and also for the attendance of Mr. Lewis, the general manager.

EXPOSITION DU TRAVAIL, PARIS.—The awards in the sixth section—Electricity—of this Exhibition are as follows:—Gold medals: MM. Lévy, Radiguet, and Aboilard. Gilt medals: MM. Arnould and Vauzelle. Silver medals: MM. Chaudron Giraud and Née, Loiseau, Perrody, Petitjean, Warnon, and Fonteuilles. Bronze medals: MM. Charlot, Cornette, Delforge, Diard, Didier, Bohne, Neveu, and Ullman. Honourable mention: MM. Cloris Baudet and Picq. The jury consisted of MM. Jarriand, Mildé, Journaux, and Armengaud.

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Cable Repairs.—In our last issue we commented upon the excellent work done by the Eastern Company's ss. "Electra" on the repair of the Direct Spanish Company's cable. The same company's repairing steamer "Volta" during the same week restored communication by the oldest cable which has ever been repaired. The cable was twenty-four years old, and the depth of water 560 fathoms. This fact is somewhat interesting, in that the life of a submarine telegraph cable has been put at ten years. Here, however, we have evidence that at more than double that age a cable will in comparatively deep water stand the rough handling attendant upon a repair.

Obituary.—The death is reported from America of William C. Hicks, at Summit, N.J., on 20th October. Mr. Hicks had been identified with several important patent suits before the United States Courts as an electrical expert, having appeared in behalf of the M'Donough interests against the American Bell Telephone Company, and for the Brush Electric Company against Conduit, representing the United States Electric Lighting Company. He was the son of Rev. J. A. Hicks, of Rutland., Vt., and was born in New York, on 21st July, 1829. He was a graduate of Trinity College, and was the first city engineer of Hartford, having since been connected with various important engineering works.

The Canadian Telegraphs.—Recent advices from Canada state that the construction of the new sections of the Government telegraph line in the north-west territories of Canada was being rapidly proceeded with. The Moose Jaw and Wood Mountain section, 93 miles in length, had just been finished, and arrangements were being made for the immediate construction of the line from Battleford to the place to be selected for the new centre in the Pitt district. The work was to be let in short sections of probably ten miles each, no one but residents along the line being allowed to tender. A line is also, it is said, to be constructed from Edmonton to Victoria, and next year the gap between Pitt and Victoria will be closed.

Electric Lighting at a Bazaar.—On the 11th, 12th, and 13th inst. Mr. Bennett (Messrs. Walker and Olliver's manager) lighted eight military camps, representing the scene of the "Field of the Cloth of Gold," at a bazaar held at the Leeds Town Hall for the benefit of All Hallows Church. The lamps used were of course incandescent, worked by one of the Gramme machines of the firm and a two horse-power simplex gas engine in the basement. The effect, we are informed, was very realistic. By means of Walker and Olliver's patent regulator the variation of the light at the explosion of the engine, which would have been painful, was almost entirely prevented, no countershafting or other mechanical complications being resorted to.

Continental Items.—The Edison lamps in the grand lobby of the Paris opera house are all in place, and a trial which recently took place has more than realised the expectations of the management.—The number of subscribers to the Société Générale des Telephones already exceeds 6,000. On the 12th instant the actual number was 6,001, against 5,464 in the preceding year. In Paris the Société have 3,969 subscribers, served by 170 telephonists. The number of communications exchanged in that city varies between 25,000 and and 30,000 daily. The mail steamer "La Normandie," belonging to the Compagnie Générale Transatlantique, has received a very complete telephone installation, carried out principally with a view to affording rapid communication between the decks, &c., and the engine rooms.

The West Coast of Africa.—The following letter from the secretary of the West African Telegraph Company appeared in a recent issue of the *Standard*:—Observing an interesting letter from your Berlin correspondent upon the subject of colonisation on the West Coast of Africa, and in which special reference is made to the Los Islands—also known as Les Iles aux Anglais—it may be of interest to your readers to learn further, as showing the wide general interest which is being awakened in these parts, that the French Government has subsidised this company to establish a telegraph station at Conakry, in that neighbourhood, on the mainland some ten miles from these islands, so that very shortly they will, by means of our cables, be placed within convenient telegraphic communication with Sierra Leone and Europe. We have no doubt but that this landing has been arranged by means of the treaty existing between the French Government and King Bala Demba, referred to by your correspondent.

The Northern District Telephone Company.—This company are pushing forward the work in their district, which extends from Whitby to Berwick, and having got the exchanges and trunk lines at Newcastle, Sunderland, North and South Shields, Tyne Dock, and Jarrow into good working order, are bringing the principal towns in the south of Durham into the circle. The first lines were opened at Hartlepool and Middlesborough last week, and the trunk line between Sunderland and Hartlepool will shortly be completed. Mr. H. C. Neave, late superintendent of the central switch room of the United Telephone Company, has been appointed inspector of the company's exchange at Middlesborough. It is proposed to utilise the loud-speaking telephone during the present state of excitement caused by the general election, as it is thought that members might deliver their addresses by this means without any of the disadvantages caused by interruptions, probably well meant but slightly embarrassing, in the shape of chair-legs and what Charles Lamb called "the coffins of untimely chickens."

Underground Cables for New York Fire and Police Telegraphs.—Our American namesake says that the 170 circuits of the New York fire department, radiating from headquarters on Mercer-street, are now connected with under ground cables leading out for several blocks in each direction. Connections have also been made with police headquarters by six special subterranean wires, and the Police News Bureau of the City Press Association at 301, Mulberry-street, by three wires to each building. The Waring lead-covered cable has been used for this work, it having been practically tested by the fire department, and found satisfactory after sixteen months' service in different parts of the city. The recent work, which is the most extensive of its character yet undertaken by the departments, was started Saturday evening, October 24, and continued day and night without cessation until finished without interrupting street traffic. Superintendents Smith, of the fire department, and Crowley, of the police department, expressed themselves as greatly pleased with its successful completion.

Telephonic Communication at Sandringham.—A very comprehensive system of telephonic intercommunication has just been completed at Sandringham for His Royal Highness the Prince of Wales, and in the arrangement of which his royal highness was much interested. An entire absence of induction effects was particularly insisted upon, and this has been very successfully accomplished by the use of specially manufactured cables, and which are laid underground in pipes. Eleven of these cables are taken from a switch-board in Sandringham House to various parts of the estate, including the

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residence of Major-General Sir Dighton Probyn, the equerries' cottage, the agent's house, and the railway station at Wolferton. Messrs. Tasker and Sons have carried out the work, using their usual telephonic combination of Johnson and Bell patents, and the clearness of articulation and the rapidity with which intercommunication can be established are prominent features of the undertaking. At the conclusion of the work his royal highness expressed in gratifying terms to Mr. Johnson his satisfaction at the marked success of the installation.

NEW BOOKS.—Messrs. Sampson Low and Co. have published a work by Mr. W. Barlow, entitled "New Theories of Matter and of Force." From the purely casual glance we have as yet been able to give to the book the new theory seems based upon the hypothesis that "all matter consists of two elementary substances, which, when uncombined and not subjected to extreme pressure, resemble gases in that they are compressible and elastic, and that, as they are freed from pressure, their tenuity becomes practically unlimited. They differ from each other in that when, being under the same initial pressure, the same increment of pressure is applied to both; the one has in all cases a greater increment of contraction than the other, and we accordingly designate them *the more readily compressible ether* and *the less readily compressible ether*, pp. 5-6. Chapters VI.-XVII. inclusive, pp. 63-200 treat of electricity and magnetism; chapter XXXV. deals with electrolysis.—"The Chemical Student's Manual," by H. L. Buckeridge, F.C.S., is published by T. Murby, Ludgate-circus.—"Transit Tables for 1886," by Latimer Clark, F.R.A.S., M.I.C.E., &c. London: E. and F. N. Spon —"Liberty and Socialism," by the Earl of Pembroke. London: Liberty and Property Defence League.

AMERICAN NOTES.—The Daft motor made another trial on the Ninth Avenue line on October 12th, with two cars and 100 passengers, from 14th to 53rd Street and back again.—Electric lighting is to be rapidly extended over the north and west divisions of Chicago. Arrangements have been completed by which central plants will be extended over those districts at once, and the Dorsett conduits will be availed of by a new organisation which promises to do thorough and complete work over large areas of territory.—The senior electrical engineers of the Massachusetts Institute of Technology have formed a society, with the professor at the head, for reading and discussing articles on electricity, as relating to engineering, &c., which appear from time to time in the various technical papers. Each student in turn prepares an abstract, which is read and discussed. Meetings are held each week.—It is proposed to fit up a sleeping car with incandescent lamps, run by the "patented chemical batteries" of the Chemical Electric Light and Power Company, and to light it continuously for three or four weeks without renewing the chemical solution. Arrangements are being made to manufacture the solution for use in every sort of battery now using bichromate of potash.

ON A DIFFERENTIAL-RESISTANCE THERMOMETER.—This consists essentially of a mercurial thermometer having a greatly enlarged bulb, so that the stem may have a diameter of something like a millimetre, and still keep the scale tolerably "open." There runs through the stem a fine platinum wire of 0·08 millimetre in diametre. The lower end may be secured in the bulb, so that it is kept straight in the bore of the stem, and at the lower end a heavier wire is sealed in the glass, so that metallic contact can be made with this wire both at the upper end and through the mercury at the lower. The resistance between these two points evidently depends largely on the length of the platinum wire which is above the mercury in the tube, and this will depend upon the temperature to which it is exposed, the resistance diminishing with rise of temperature by an amount equal to the difference between that of the platinum wire which disappears and that of the mercury which takes its place, less the increase in the resistance of the platinum wire and the mercury due to rise of temperature. Mr. J. C. Mendenall considers this method has an advantage over the use of a simple resistance coil (which the late Sir William Siemens applied in his well-known electrical pyrometers and thermometers), in that the change in resistance accompanying a given change in temperature is much greater, and may in fact be made as great as desired. As a result the telephone may be substituted for the galvanometer in the resistance measurements, or less sensitive galvanometers may be used.—Abstract *Proc.* Inst. C.E.

NEW SCIENCE AND ART SCHOOL.—As a memorial to the late Sir Titus Salt, and in recognition of his benefactions to Saltaire, the Governors of the Salt Schools have decided to build a new science and art school, costing about £6,000. The building will be completely finished by May 15, 1886, on which day will be opened an important exhibition on the lines of the late International Inventions Exhibition. For this purpose the present buildings and a field of six acres will be utilised, the whole being named the "Palace of Delight," in allusion to the ideal institution delineated in Mr. Walter Beasant's "All Sorts and Conditions of Men." Accommodation will be provided for over 10,000 people, and the affair will be the largest of the kind ever seen in the provinces, the probable outlay being over £15,000. With the object of attaining the utmost excellence, space will be allotted only to the most eminent firms in every conceivable branch of industry. Amongst other exhibits will be the South Kensington collection, and the Prince of Wales's Indian collection. The grounds already alluded to will be planted, and illuminated with the electric light, having fountains similar to those at the Inventions Exhibition, illuminated with coloured electric lights. In view of the variable climate, an enormous tent of the American description will be put up in the grounds, capable of holding several thousand people. The arrangement and supervision of the lighting and other electrical work, including the contract of the installation and maintenance of the electric light in the buildings and grounds, have been entrusted to Messrs. Woodhouse and Rawson, of London.

THE NATIONAL TELEPHONE COMPANY.—The fifth annual *conversazione* of the *employés* and friends of the Glasgow district of the above company was held in the St. Andrew's Hall on Friday evening, 13th inst. The assembly was a most successful one, dancing commencing at 8:30. At ten o'clock there was an interval, during which tea was served, after which W. A. Smith, Esq., president-director, took the chair. In his address the chairman drew attention to the extension of and improvements in the company's system throughout Scotland for the past year—by Mr. Bennett in the eastern district, and by their own engineer, Mr. Sinclair, in the west. In those extensions and improvements in the telephone world Glasgow had kept well to the front. Among the improvements he referred to their new switch room in the Royal Exchange Buildings, into which they had introduced the most improved apparatus. Drawing attention to the difficulty that had been experienced in giving to the public the use of the telephone without becoming subscribers, he mentioned that shortly the company would be able to do this by mechanical means, as Mr. Sinclair, along with another gentleman, had invented a very ingenious piece of apparatus whereby this could be done. He said he did not wish to trouble the meeting with statistics, but would just give a few figures to convey an idea of the number of messages that passed over their wires.

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During the past week over 300,000 messages were sent, making a grand total of 16,000,000 for a year. Songs were tastefully rendered during the evening by young ladies from the switch rooms, and dancing was sustained with unflagging zest until an early hour in the morning.

THE ELECTRIC LIGHT AND THE SUEZ CANAL.—In presence of the continued increase in the traffic through the Suez Canal, even during the present commercial crisis, and to provide for the still greater increase that is anticipated in consequence of the abolition of the pilot dues and the lowering of the tariffs, by which merchandise now reaching Europe from the East and from Australia by the route round the Cape will be able to be sent through the Canal, the company has for the last two years been making experiments with electric lights, with a view to enable vessels to continue their passage through the Canal during the night. These experiments have at length proved so successful that it has been resolved to permit from the 1st of January next all vessels of war and postal steamers provided with the requisite electric lights to navigate by night in that portion of the Canal comprised between Port Said and kilometre fifty-four. Therefore, in almost half that portion of the Canal where ships have to put into sidings to allow other vessels to pass them—in the Bitter Lakes vessels pass each other without stopping—vessels of war and mail boats, that together represent twenty-two per cent. of the total traffic, will be able to continue their passage at all times of the day and night. This will constitute a great saving of time, and M. de Lesseps in his circular expresses the confident hope that the trial will be so successful as to enable him to authorise, within a short delay, night navigation for all descriptions of vessels throughout the whole length of the Canal. The rules and regulations for this night navigation appear very clear. Each vessel is to carry the electric light destined to light up the Canal for twelve hundred metres, or just three-quarters of a mile ahead, and thus to enable the ship to navigate in the Canal with safety.

ELECTRIC LIGHT INSTALLATON AT NEWCASTLE.—The new flour mill of Messrs. J. Davidson and Son in this town is now lighted throughout by electricity on the incandescent system, the entire installation having been carried out by Messrs. Clarke, Chapman, Parsons, and Company, of Gateshead, and consists of about 200 lights, eighteen of these being of 50 candle-power, and the remainder of 20 candle-power. Those in the milling room are placed in opal glass shades hung from the ceiling, and ten are in portable lanterns connected by flexible wires to the main cables, and serve as search lamps for examining the interior of the machines. Two clusters of six 50 candle-power lamps light the warehouse, and a lantern with six 50 candle-power lamps is suspended on the jetty. In the engine room there are fifteen 20 candle-power lamps in handsome venetian shades on polished brass brackets fixed on the pitch-pine dado. The current for these lamps is supplied from one of Messrs. Clarke, Chapman, Parsons, and Co.'s patent electric generators (motor and dynamo combined) of the compound turbine type, fitted with self-acting automatic lubrication and electrical-control governor. This machine, which is capable of supplying current for 250 twenty candle-power lamps, runs at the high speed of 9,000 revolutions per minute, without, the makers allege, the slightest amount of heating. The friction is said to be almost *nil*, it having practically but one moving part. Messrs. Clarke, Chapman, Parsons, and Co. had two of their machines running at the Inventions Exhibition, lighting part of the refreshment rooms of Spiers and Pond. They have also just completed the lighting of Lincoln's-inn Halls, London, and of the large Wilson liner, the ss. "Buffalo," built by Messrs. Palmer's Shipbuilding and Iron Company, Jarrow, and launched a few months ago, besides several other installations.

SEEING BY ELECTRICITY.—On being asked a question as to the possibility of seeing long distances by means of electricity, Prof. Bell replied: "That is the question which is now being asked on all sides, one which I can answer affirmatively. I cannot tell how soon. I only know that the problem is so nearly solved as to encourage investigators to persevere a little longer. I know of at least a half dozen men at work on the subject. The reason why I know is amusing. Several years ago I was experimenting with the problem of the photophone. As you may remember, a ray of light from the sun was the motive power, and selenium the important feature of its construction. When I had solved this problem I deposited a description of my discovery in the Smithsonian Institution without giving any information to the authorities as to what the sealed packet contained. Some persons began to speculate as to the probable nature of the discovery hidden in the packet. Not long afterwards, the London *Nature* stated in a paragraph that I had solved the problem of seeing long distances, and that full particulars of the discovery were contained in a sealed packet deposited in the Smithsonian Institution. Instantly six investigators rushed into print in their respective localities to say that they had already solved the problem, and protesting against my alleged assumption of priority. In New York a Mr. Sawyer wrote claiming the invention. The sealed packet became an object of tender solicitude. I had at that time never given any attention to the subject. Although the indignant six claimed the invention, no one has yet ever seen any one else at long distances, nor has any instrument been exhibited which looks like solving the problem. I think I can say, however, that it will not be long before you can sit in a a room and converse with your friend far away, yet automatically by your side."

RAILWAY CARRIAGE LIGHTING.—In an article upon this subject, *The Times*, after discussing the merits of compressed coal-gas, says that:—"Another system, the merits of which have been discussed, is that of electric lighting. But in the discussion the fact has been lost sight of that what has been done in the way of lighting railway carriages by electricity has been effected in the main at the expense of the patentees or their representatives, without the pockets of railway shareholders being in the least degree affected. Of the schemes which have been brought before railway managers and engineers for lighting trains by electricity, it may be said that their name is legion. But, notwithstanding this, there appear to be only about six trains running at the present moment which are lighted in this way, while some four others have been standing still for such a long time that the suspicion is gaining ground that the carriage superintendent has decided after trial to take off the fittings. The electric lighting of trains would appear to be in pretty much the same condition as the electric lighting of streets and buildings. Sometimes one system is tried and sometimes another, but nothing is definitively adopted and settled. Looking round generally, it appears as though—the Paddington experiment excepted—there is less electric lighting to be seen than there was two years ago." This latter statement is one to which we give an emphatic denial. As regards street lighting in London there is, perhaps, not so much to be seen as when the electric light was brought forward for no other purpose than to forward the views of a whole host of speculators. The light has now to be *paid for*. Therefore, there is less gratuitous display. The electric lighting industry is, however, going ahead. There are but few places where the new illuminant is not to be seen, and

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no one who has eyes for more than one locality will support the assertion we have quoted.

The Indian Government Telegraphs.—The *Homeward Mail* says that the Indian press is calling for an inquiry into the condition of the Government Telegraph Department, and the cause of the prevailing discontent among its officers. Certain remedial measures, proposed by the Indian Government, appear to be altogether inadequate; and it is to be hoped that no time will be lost in appointing an impartial committee to hold an inquiry, in India, into the grievances of one of the hardest-worked and most harshly treated branches of the public service. The matter has been commented upon from time to time in our columns. It remains now to be seen whether the Government can be forced into the adoption of remedial measures by the pressure of public opinion. The aggrieved officials are by no means destitute of hope. A Defence Committee has been formed for the purpose of bringing their troubles to the notice of Parliament. The principal grievance is of course slowness of promotion; but there are others, though of a minor character, equally in need of redress. "Go where you will," says an indignant correspondent in the columns of an Indian paper, "and you will hear the same story; difficulties in obtaining leave long over-due; frequent and sudden transfers of officers from one end of India to the other without any apparent cause, which invariably occasion great inconvenience, and frequently involve a much greater expenditure than is covered by the travelling allowance granted by Government; the curt and offensive tone of correspondence from some officers; the withholding of local allowances granted to officers of similar rank in other departments; the practice, which has been steadily increasing, of keeping working parties out in camp throughout the hot weather, in spite of an old standing order to the contrary, on works of no real urgency, such as the opening of an unimportant postal telegraph office; juniors doing the work of seniors who draw the emolument—for instance, the junior second grade superintendent holding charge of Bengal, the most important division in India, an appointment which in other services would be held by the senior superintendent of the department; delays in gazetting permanent and temporary promotions."

Sir Frederick Abel on Mining.—At the Society of Arts on Wednesday evening, the opening address of the 132nd Session was delivered by the chairman of the council, Sir Frederick Abel, the subject chosen being that portion of the exhibits at the late Inventions Exhibitions which consisted of the machinery and appliances used in mines. After referring to the terrible dangers incurred by our mining population, Sir Frederick said that considerable interest in particular must be felt in the labours, now fast drawing to a close, of the Royal Commission appointed about six and a half years ago to inquire whether the resources of science could furnish any practical expedients, not then in use, which might be calculated to prevent the occurrence of accidents in mines. Upon the important topic of safety lamps, he pointed out that until within a comparatively recent period only three types of lamp were in extensive use in this country—the original safety lamps, which the miners owed to the genius of Davy and Stephenson; and a lamp not long afterwards devised by Dr. Clanny. These lamps were now useless, and so clearly established was the danger of relying upon them that the commissioners considered it their imperative duty to direct the special attention of the Home Secretary to the matter. At the same time the commissioners had indicated with confidence several lamps which combined a great degree of safety with simplicity of construction and fair illuminating power. The electric light had been looked to as capable of furnishing the kind of lamp required, but the application of it to the purpose had been found difficult, for the fracture of a glow lamp, or the rupture of a conducting wire in a mine, might be as dangerous as an injury to a safety lamp or the lighting a pipe. The recent considerable improvements which had been made in accumulators and in constant primary batteries had led to very important progress towards the attainment of the desired result. Mr. J. Wilson Swan among others had gone patiently to work, and had succeeded in producing a lamp which, with its small storage battery, weighed little more than 8lb., and which furnished a light equal to from two to four times that given by the better forms of safety lamp for a duration of ten or twelve hours. One of these lamps, which are, of course, independent of any outside battery or connecting wire, was exhibited together with some of the older forms of safety lamps.

A Complaint.—Not long ago a deputation of the residents of Gloucester-crescent attended at the Marylebone Police Court to ask for assistance in a matter which they said was of very great importance to them. It was explained that the Great Western Railway Company, for the purpose of lighting their premises and the line between Paddington Station and Westbourne Park, had recently erected in the immediate rear of Gloucester-crescent machinery of so powerful a character that the houses in the neighbourhood were made almost uninhabitable. The machinery had latterly been at work night and day, Sunday included. The tremendous vibration and noise, added to the fumes of smoke, steam, and the dirt caused by the machinery, produced such a nuisance as to be almost unbearable. The noise of the machinery destroyed all quietness during the day time and sleep was interfered with at night. Such an annoyance, it was said, must obviously be a nuisance, and injurious to health, and they asked the magistrate, in the name of the inhabitants of the neighbourhood, some of whom had been in the occupation of their houses for upwards of 20 years, to grant them a summons against the company. Mr. De Rutzen reminded the deputation that a similar application had been made to his colleague, Mr. Cooke. The deputation said that they were aware of that, and that difficulties of a technical kind had arisen, but they were prepared to ask for a summons. Mr. De Rutzen remarked that some time ago he was asked to join with others to put down a similar cause of complaint in a street near Piccadilly, where there was the strongest possible evidence of the existence of a nuisance. Counsel's opinion was taken, and as a result an injunction in Chancery was applied for and granted. The deputation replied that they were anxious for process in this court, as it was most important that as much time as possible should be saved, and besides there was the question of expense. Mr. De Rutzen said that if a summons were granted for a nuisance it would be necessary to call scientific evidence to show that it was injurious to health. The deputation informed the magistrate that the machinery in use was said to be more powerful than that used at the Inventions Exhibition. Mr. De Rutzen said that if the deputation would draw up an information, setting forth the facts on which they relied, he would communicate with Mr. Cooke, who had been already consulted in the matter, and let them know the result. Replying to the magistrate, the deputation said that the company had been communicated with, and although an abatement of the nuisance had been promised, there had not been any sensible lessening of the cause of annoyance.

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RETROSPECTIVE NOTES.

The ignorance shown upon many matters relating to the applications of electricity is very great. Nor is this to be regarded as wonderful. The major portion of those interested in the subject have had their attention directed to electrical work under exceptional circumstances. When, however, we can impress upon men the necessity of obtaining trustworthy information on the subject, they will perhaps be led to inquire into what has been done, and what can be done, instead of blindly accepting whatever interested parties may say. The idea of perpetual motion is scorned amongst educated classes—indeed, the ploughboy is almost sufficiently educated to show its impossibility—but highly educated people, and keen men of business, are even now ready to believe anything and everything they are told about electricity. The following Retrospective Notes will show that many developments of to-day were foreshadowed in years gone by. In 1836 the following sentences were published :—

"Since we are on the chapter of coal mines, it seems to us that here is the place to express our astonishment at seeing that one of the most beautiful discoveries of modern science has not been rendered available for the illumination of the galleries. We would speak of the incandescence of charcoal produced in vacuum by means of a voltaic pile. . . . . . There would not be the least fear of danger, since the focus of light would be completely insulated from the external air."

The time of incandescent electric lighting had not in 1836 come. The idea was there, but the dynamo was absent. In 1845, however, the incandescent electric light was actually employed to illuminate a mine. Of course it failed to hold its own, not because of failure in the light, but because of its great cost.

The improvements in incandescent lamps since those days have undoubtedly been great, but they are improvements and nothing more.

In 1848 a combination of permanent magnets with electro-magnets was used for the purpose of increasing the action of the former, the manner of such combination being still further explained as "combining and applying permanent magnets within 'hollow coils' (in connection or not with electro-magnets) to obtain an increase of power at a distance from the main battery."

A striking description of compound winding (used for telegraphic purposes) is given in 1849. Thus:—

"To use weak galvanic currents in electric telegraphs, the electro-magnets carry the insulated coil of the local battery *as well as that of the line wire circuit* (the italics are ours), thus uniting, reducing, or neutralising their efforts."

It will be unnecessary to follow history year by year in connection with this one phase of electrical work; but while we have carefully avoided giving names and references hitherto, we may do so in the following. The *Proceedings* of the Royal Society, Vol. XV., 1866-7, contain, p. 367, the paper by C. W. Siemens, F.R.S. (received February 4th, 1867), "On the Conversion of Dynamical into Electrical Force without the Aid of Permanent Magnetism," followed, p. 369, by the paper of Charles Wheatstone, F.R.S. (received February 14th, 1867), "On the Augmentation of the Power of a Magnet by the Reaction thereon of Currents Induced by the Magnet Itself." These papers of Siemens and Wheatstone led to other papers by Clerk-Maxwell and Ladd, &c., and a letter by C. F. Varley. The letter of the late C. F. Varley, F.R.S., contains this remarkable paragraph :—

"The force expended in the shunt is wasted in heat; *but a secondary wire on the electro-magnet* (the italics are ours), or a copper cylinder would very greatly add to the power by maintaining the magnetism, and not consume uselessly the force now wasted on the shunt."

We will go back again to the year 1850, just to give one more note on this particular subject. A magneto-electric machine was then designed, "with coils both round armature and magnet," though the inventor evidently did not know how near he came to the solution of a great problem.

It will be remembered that one of the early arc lamps introduced from America consisted of carbon plates or carbon discs, the arc running backwards and forwards between the plates. In 1845 a patent describes "circular discs of carbon mounted on axes revolving in bearings . . . the discs are made to revolve with a slow, uniform motion. In order to bring about the desired effect two neighbouring discs connected with opposite poles of the same battery are brought into contact, and, as soon as the points of contact are sufficiently ignited, the discs are to be withdrawn out of contact, when a brilliant and permanent electric light will be evolved."

Some ill-disposed persons who have a prejudice against all things not cockneyfied have gone so far as to say that the keen Yankee, in the time of the electrical boom, hunted out old patents, re-patented their contents, and sold his work for a goodly sum. We have often stated that only a small percentage of patents issued by the Patent Office contained new ideas. Yet we did not imagine that plagiarism in patents was quite so bad as it is till after a long investigation. There can be hardly a doubt, however, but that some American patents are deliberate copies of prior English patents. The subject is not a nice one, and we will leave it.

M. J. Roberts, in 1852, describes a mode of obtaining electric light by passing electricity through a thin piece of graphite enclosed in an exhausted glass globe.

Many readers will understand why these notes are given. A secondary object is to induce those interested in electrical work to be less hasty in believing any invention brought to their notice to be new, and to defer somewhat more than at present to the judgment of technical electrical journals.

β. γ. σ.

THE STEAM ENGINE INDICATOR.—IX.*

BY AMICE.

We may now take, as a simple example of a diagram from a high-pressure non-condensing engine, the one given below, which is from a portable engine by a good maker, but which had been at work several years, without any repairs or adjustment, when the diagram was taken. A thrashing machine was being driven, and the diagram was obtained when the machine was running empty, so that it indicates the power employed simply to work the engine and machine without doing any thrashing.

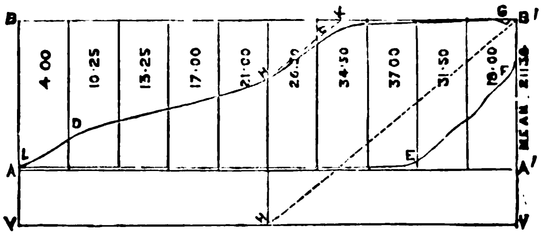

FIG. 35.

The engine had a cylinder 8·5 in diameter and a stroke of 1ft. When the diagram was taken it was running at 115 revolutions per minute, and the boiler pressure was about 47lb. per square inch. The engine was fitted with a common slide valve, with lap sufficient to cut off the steam at about one-third of the stroke, and with a governor and common throttle valve which reduced the initial pressure in the cylinder to that shown on the diagram.

The diameter of the cylinder being 8·5in., the area of the piston was 56·74 square inches. The diagram (Fig. 35) is one of a large number taken during an experimental test of the machine; and it being necessary to take out the indicated power as shown with the machine working under different conditions, the practice of using a constant to simplify the work of calculation, was adopted, and of this we may take an example. The constant for an engine is simply the number which represents the power of the engine per lb. pressure on the piston. In our case, then, it will be

$$\frac{56{\cdot}74 \times 115 \times 2}{33{,}000} = 0{\cdot}3954.$$

* For Art. 8, see *The Electrician*, 13th November, 1885.

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Our diagram gives us a mean pressure of 21·3lbs. pressure throughout the whole stroke. The indicated horse-power of the engine is then $0·3954 \times 21·3 = 8·42$. This, however, is only as indicated by one end of the cylinder. The diagram from the other end showed how necessary it is to take diagrams from both ends of a cylinder and never to rely upon that from one end only. The adjustment of the slide valve being inaccurate the mean pressure was reduced to 18·3lbs., giving only 7·23 horse-power. The mean indicated horse-power was thus not 8·42 but $8·42 + 7·23 \div 2 = 7·82$.

In small engines the reduction in the effective area of the piston which is made by the piston rod is often—we might say generally—neglected. In larger engines it should be taken into consideration, and we may take this opportunity of an example of its effect. It will of course be very small in so small an engine, but not too small to give some idea of the necessity for making the reduction when the piston rods are large.

In our case the piston rod was 1·5in. diameter; this represents an area of 1·76 square inch, and by this area that of the piston will be reduced at one side, so that the effective area will be reduced by $1·76 \div 2 = 0·88$in., and will equal 56·74 - 88in. = 55 86. Our engine constant will then be $\frac{55·86 \times 115 \times 2}{33,000} = 0·389$. Taking our pressure as the mean of the pressures from the two ends of the cylinder, or 19·8lbs., we have the mean indicated horse-power of the engine $= 0·389 \times 198 = 7·70$, so that the piston rod occupies an area which reduces the power in this small engine by an eighth of a horse-power.

The diagram we have here used is not put forward as an example either of good diagrams or good steam performance, but is taken as illustrating what would be obtained from a very common type of engine, and it shows a good many points to which we must refer hereafter. In our engraving we have marked the atmospheric line A A′, the line of maximum pressure at B′ has been produced to B, so as to form with the vertical lines a parallelogram enclosing the diagram. In tracing the indicator pencil as it produced this diagram, we will commence at L—namely, at the beginning of the return or exhaust-stroke. The diagram is here very near the atmospheric line, the pressure in the cylinder during the exhaust-stroke, or back pressure, being not more than 1lb. per square inch until it nears the last fourth of the stroke and the exhaust port is nearly closed. At E the exhaust port closes, and the vapour left in the cylinder is compressed by the piston as it completes its stroke. The pressure of this compressed exhaust vapour rises to F, or to about 26lb. per square inch. At F the steam port opens and steam is admitted while the piston has yet about one-sixteenth of an inch of its stroke to complete—that is to say, the valve is set with a sixteenth of an inch lead. The sudden admission of the steam drives the indicator pencil up to G above the normal maximum, and the spring in its recoil brings the pencil somewhat below this line. After this a clean line is drawn, the pencil falling gradually as the valve slowly cuts off the steam, the fall in pressure towards C being the result of the wire drawing, as it is termed, which is caused by this slow closing of the port. When a steam port is closed slowly, as it is by an ordinary slide valve without much lap, the pressure in the cylinder falls in consequence of the increase in the velocity of the piston which takes place as the port opening is being reduced to nothing, so that the passage gradually becomes too small to permit the steam to enter the cylinder at a rate sufficient to maintain the pressure behind the piston. A little before the pencil arrives at C steam is cut off and expansion begins, the fall in pressure being rapid at first between C and H, and from this point it is gradual, the slowness of the fall indicating re-evaporation of steam condensed during the previous part of the stroke. At O the exhaust port opens and the pressure falls to near that of the atmosphere at L when the stroke is completed.

Viewed with reference to economy this diagram shows too much compression for the speed of the piston, which is only 230ft. per minute; throttling, slow cut off and wire-drawing, and unnecessarily high pressure at exhaust. Other points to be dealt with by reference to this diagram will be considered hereafter, but before proceeding with these and with diagrams from compound engines we will take a typical condensing engine diagram and a theoretical diagram into consideration.

THE FIRST TRANSMISSION OF POWER BY ELECTRICITY.

At the present time the idea of using two dynamo machines placed at a considerable distance for the transmission of power is so well known as to cause no more surprise than the transmission of the power of a steam engine to the various machines in a factory by means of shafts, belts, or ropes. At the generating station we have a dynamo driven by some prime mover; we have then two insulated wires leading to the point where the power is required, and there we recover part of the energy of the prime mover by means of a second dynamo machine acting as electro-motor. All this is well known, and is now accepted as an established fact, which is as simple and self-evident as the law of gravitation. But there was a time when even this simple and familiar application of electricity was shrouded in mystery, and a *bonâ fide* invention or discovery was necessary to bring it to life.

It is always interesting to go back to the first dawn of a new invention, but it is not always easy to determine whether it was the result of accident, necessity, or the outcome of clear, intelligent foresight on the part of the inventor who was working for a particular purpose. As regards the first transmission of power by electricity, opinions are divided. According to M. Figuier, accident pure and simple, was the cause of the discovery. He relates that at the International Exhibition in Vienna in 1873 the Gramme Company had two machines on view intended for lighting purposes. One of these machines was in motion, and a workman who noticed that some cables were trailing on the ground, and thinking they belonged to the second machine, placed them in its terminals. To the surprise of everybody this second machine, which had been standing, began to turn of its own accord. Then it was discovered that the first machine was working the second.

This story is romantic, but disappointing to a true lover of science, who would prefer to believe that a great discovery was the logical outcome of the working of a powerful intellect, and not the result of accidental meddling on the part of an ignorant workman. But there is another version of the story, told by M. Hippolyte Fontaine to the Société des Ancient Eléves des Ecoles Nationales d'Arts et Métiers a few months ago. M. Fontaine claims to have actually invented or discovered the electrical transmission of power, as will be seen from the following short abstract of his paper read before the abovementioned society :—

"On the 1st of May, 1873, that is on the date fixed four years previously by Imperial decree, the Exhibition in Vienna was formally opened. At that time the machinery hall was yet incomplete, and remained closed to the public until the 3rd of June, when it was also thrown open. I was then engaged with the arrangement of a series of exhibits, shown for the first time in public, which were intended to work together, or separately, as desired. There was a dynamo machine by Gramme for electroplating, giving a current of 400 amperes at 25 volts, a magneto machine, which I intended to work as a motor from a primary battery, or from a Planté accumulator to demonstrate the reversibility of the Gramme dynamo. There were also a steam engine of my invention heated by coke, a domestic motor of the same type heated by gas, a centrifugal pump placed on a large reservoir, and arranged to feed an artificial cascade, and numerous other exhibits. To vary the experiments I proposed to show, I had arranged the pump in such a way that it could be worked either by the Gramme magneto machine or by the steam engines (Fontaine).

"On the 1st of June it was announced that the machinery hall would be formally opened by the Emperor at 10 a.m. on the day after the morrow. Nothing was then in readiness

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but those who have been in similar situations know how much can be got into order in the space of 48 hours just before the opening of a great exhibition. In every department members of the staff with an army of workmen under their orders were busy clearing away packing cases and decorating the spaces allotted to the different nations. These gentlemen visited all the exhibits in order to determine which of them should be selected for the special notice of the Emperor, so as to detain him as long as possible amongst the exhibitors of their respective countries.

"M. Roullex-Duggage, who superintended the work in the French section, asked me to set in motion all the machinery on my stand, and especially the two Gramme machines. I set about at once, and on the 2nd of June I had the satisfaction of getting the large Gramme dynamo, the two engines (Fontaine), and the centrifugal pump to work; but I failed to get the motor into action from the primary or secondary battery. This was a great disappointment, especially as it prevented my showing the reversibility of the Gramme machine. I was puzzled the whole of the evening and the whole of the night to find a means to accomplish my object, and it was only in the morning of the 3rd of June, a few hours before the visit of the Emperor, that the idea struck me to work the small machine by means of a derived circuit of the large machine. Since I had no leads for that purpose I applied to the representative of Messrs. Manhis, of Lyons, who was kind enough to lend me 250 metres of cable, and when I saw that the magneto machine was not only set in motion, but developed so much power as to throw the water from the pump beyond the reservoir, I added more cable until the flow of water became normal. The total length of cable in circuit was then over two kilometres. This great length gave me the idea that by the employment of two Gramme machines it would be possible to transmit mechanical energy to great distances. I spoke of this idea to various people, and I published it in the *Revue Industrielle* in 1873, and subsequently in my book on the Vienna Exhibition. The publicity thus given to it was so great that I had neither time nor desire to protect my invention by a patent. I must also mention that M. Gramme has told me that he had already worked one dynamo by the other, and I have always held that the honour of my experiment belongs to the Gramme Company."

A PORTABLE ELECTRIC LAMP.

A useful form of lamp, fed by a primary battery, is being manufactured by Messrs. Huon and Collet, of Hatton-garden. A neat wooden case of about 1ft. in height by 6in. square, carries four small bichromate cells and four sets of plates. The incandescent lamp, taking 9 volts and three amperes, gives a continuous light of rather over eight candles for an hour and a half; a very fair result. Referring to our illustrations, P (Fig. 1) is a handle by means of which the movable india rubber cell C, containing the exciting bichromate of potash solution, is brought into contact with the plates of the battery H, which latter are connected with the terminals B B at the top of the apparatus. S is a clamping screw working in a slot cut in the case, and serving to regulate the height to which it is desired to raise the cell C, or, in other words, to diminish the intensity of the light, if such be required, by lessening the plate-surface immersed in the solution. D is also a clamping screw to fix the cell in position for transit or for giving light when the apparatus is set down. Z Z Z Z are screws to which the zinc plates are attached in order to facilitate removal, and L, R, K, and E are of course the lamp, its holder, and reflector; which latter fits into the wooden cylinder K. There is of course nothing novel about this lamp, but it is very cheap and very good. Its chief fault is that it is rather heavy—not excessively so, but greater than is perhaps necessary. However that may be, we think that it will find favour, not only among surgeons, dentists, and others, but with those who require a handy light for the bedside or for moving about the house at night. There is nothing complicated in its construction. The cell, C, is easily taken from the case, a turn of a screw releases the lamp, and when necessary the plates may be removed without trouble. For the use of medical men the apparatus is provided with a small auxiliary lamp (Fig. 2), and a cauterising instrument, with holder and conducting wires (Fig. 3), of too simple a

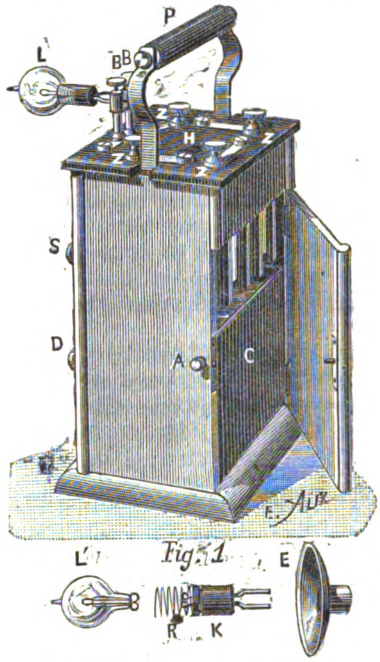

Fig. 1

nature to need explanation. The hand lamps are, we believe, made in three sizes, *i e.*, No. 1, taking 7 volts and 2 amperes; No. 2, taking 8 volts and 2·5 amperes; and No. 3, 9 volts and 3 amperes. Our experiments have been conducted with the latter size, and as a result we are satisfied that its manufacturers have in no way exaggerated their claim to the

Fig. 2

Fig. 3

production of an economical and efficient apparatus, as compared with other lamps of the kind.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the re-assembling of this society for its winter session, on the 12th inst., Major-General Webber, C.B., R.E., read a paper describing the operations of the military telegraphs, of which he was director in Upper Egypt and the Soudan during the campaign of 1884-5. When the expedition was decided upon the first thing he (General Webber) had to see to was the condition and extent of the existing communication south of Cairo. A telegraph had long been erected as far south as Dongola, and even to Khartoum, but it was in bad condition, and for some time past the whole system above the Mudir of Dongola's district had been utterly dismantled. Between Cairo and Assiout, a distance of 229 miles, there were three wires,

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with a fourth for part of the distance. Only one of these was a through wire, the others being for railway and private messages between these two places. Beyond Assiout there was a single wire to Assouan, 320 miles long, worked by single needle instruments, with numerous intermediate stations. To Wady Halfa, a further distance of 210 miles, a single wire existed, but in a very dilapidated condition, the poles being rotten with the attacks of white ants, and the wires repaired at frequent intervals with dry joints; and from Halfa to Dongola stretched another line 230 miles long, passing over a most desolate, rocky, sand-drifted region, with but few spots intervening where any linesmen could exist to look after the repairs. For the purposes of the expedition, when it arrived the line had to be extended as far as Korti and neighbourhood; but long before then the whole length of permanent line between Cairo and Dongola, 1,000 miles apart, had to be gradually got in working order so as to meet the demands likely to be made upon it as the forces advanced. Faults, of course, were of hourly occurrence, the delay was excessive, even for ordinary traffic, complete breakdown was frequent, batteries had not been replaced for nearly twelve months, and the operators were of a very inferior class. All the wires leading into Cairo passed through the palace; but by the courtesy of the Khedive this element of *espionage* and delay was done away with, so far as the through military telegraph was concerned. Thirty first-rate telegraphists arrived from England, and with their aid the army telegraph construction men gradually got the whole length into tolerable working order. The necessity for pushing on, however, arose in due time; the suspended wire across the cataract at Halfa having broken, it was replaced temporarily by a military ground cable, submerged under the river, an experiment which answered well until a better armoured cable arrived. South of Halfa most of the iron poles of a line of superior construction, which had formerly stretched into the heart of the Soudan, but which had been destroyed, had to be replaced as best could by branches of trees stuck in the ground, and to which the wires were affixed. At some parts of the route the drifting of sand was so great and constant that, as it reached the wires, the custom was to fasten another pole to the lower one, and so raise the wire until this was again in danger of being buried by fresh accumulations of drift. In certain situations this process had been repeated so often that sometimes the wire stood three or four poles higher than its original position. Elsewhere the overflow of the river destroyed the stability of the poles; and where these interfering causes were not at work the inroads of the white ant would soon so enfeeble the erection that the blow of a stick would cause it to crumble to the ground. Superior apparatus arrived from England, thanks to the Post Office authorities, designed to enable duplex working to be introduced; but by that time the traffic had so greatly increased day and night that no opportunity arose for effecting the necessary change. So slow was the means of transit that the cases sent forward by the Post Office in October did not reach Korti till the end of December. Usually the sounder with relay was employed; but sometimes the efficient current was so feeble that a vibrator sounder had to be inserted and the reading done by telephone, which was also used with great advantage for testing purposes. The heliograph was employed only on few occasions, although in General Webber's opinion the atmospheric conditions of Egypt were, in spite of mirage, favourable to heliographic signalling. But the difficulty of camel transport prevented the use of this valuable instrument in many positions where it would have done excellent service, but where instead field signalling had to be resorted to. General Webber paid a high compliment to the signalling corps, and took that opportunity of expressing his strong conviction that the whole body of signallers, both telegraphic and visual, should be placed under one controlling organisation. After furnishing some statistics of the enormous amount of traffic disposed of, the lecturer conveyed his high appreciation of the admirable manner in which the Eastern Telegraph Company had performed their part of the work, and of their liberality in allowing certain messages of painful purport to pass over their wires free; and concluded with a warm eulogy upon the zeal, devotion, and loyalty of all the men under his direction during the campaign.

Several officers, both of the army and navy, offered some brief observations upon General Webber's paper, amongst whom were Colonel HARRISON, who attributed the success of these and similar operations of recent date, first to the excellent organisation, second to the character of the stores, which were the best that money could obtain, and last, though not least, to the hearty co-operation which prevailed between the postal telegraphs of this country and the military service; Colonel BERESFORD, who gave some account of the expedition to Suakim in the direction of Berber, mentioning a circumstance altogether unique in military history, namely, that the telegraph was extended into the very thick of the fight on the occasion of the surprise of General M'Neill's zareba; Captain HAMMILL, senior officer of the Nile transport service at Wady Halfa, gave his testimony to the admirable service rendered by the telegraph to the Nile boat expedition; Mr. OATWAY, who had been in charge of the clearing house of the Soudan telegraphs, furnished detailed particulars of the traffic and revenue; and Prof. FORBES related some of his experiences with the Russian army telegraphs during the Turko-Russian war. A hearty vote of thanks to General Webber concluded the proceedings.

LEGAL.

Wheatley v. Consolidated Electric Light Company.

In the Chancery Division of the High Court of Justice, before Vice-Chancellor Bacon, on the 18th inst., this case came on for hearing.

Mr. MARTEN, Q.C. (with whom was Mr. E. Beaumont), said this was an action to restrain a nuisance caused by the noise and vibration of the defendants' steam engine and dynamo engines. The plaintiffs were Mr. William Wheatley, the tenant, and the Monarch Investment Building Society, the landlords, of an hotel or refreshment place called the Three Compasses, at 66, Cow Cross-street, Smithfield. The defendants occupied 66A in the same street, which was at the rear and on the south side of the plaintiffs' premises. The steam engine was in the basement, the dynamos were on the ground floor, and a party wall separated the defendants' from the plaintiffs' premises. The shaft of the engine was supported by girder bearings fixed into the party wall and thence resulted a noise and vibration which seriously inconvenienced the plaintiff's customers, and had already occasioned him so much injury that he claimed £1,000 as damages. The defendants denied all the plaintiff's statements, and alleged that the machinery had been working from May, 1883, to the present time; but no complaints were made until September, 1884. The plaintiff Wheatley asked for an inquiry as to damages.

The plaintiff was examined, and said the defendants' works adjoined his dining room. He entered the premises on May 19, 1883, and almost immediately felt an annoyance from the shaking of the building and a rumbling noise, which continued from eight o'clock in the morning to eight at night, with one hour's cessation in the middle of the day. Customers had been so much annoyed by the noise that they left the dining room saying they would never come again. The shaking moved the knives and forks on the table, and the empty bottles down below. In the bed room the shaking was felt more than the noise. There had been a falling off in the business to the extent of about £50 to £60 a month. The receipts were nearly £250 a month when witness entered into possession, and they had gradually decreased, with some occasional increases, to £161; but in October of the present year they were £198. Witness attributed the falling off entirely to the noise keeping gentlemen away from the dining room. The position was close to the Meat Market. Witness complained to the defendant company soon after he took possession, and they said they could not be bothered by such complaints, and it would be worse when they got down two or three more dynamos; this answer was given by a man named Taylor. The noise was worse at some times than at others; it had not been quite so bad during the last three months.

Cross-examined by Mr. HEMMING, Q.C.: The directors of the defendant company came on October 2nd to hear what the noise in the dining room was, but they scarcely spoke to witness. There was a falling off in business generally, owing to the universal stagnation. Witness could not say how much of the decrease in his business was a falling off in the dinners. The neighbourhood itself was somewhat noisy. Witness's premises were near the Metropolitan Railway, within 12 or 15 feet; but he did not know there were three trains a minute on the line. There was some vibration from the trains, but nothing like what was caused by the defendants' engines.

The VICE-CHANCELLOR: The trains are not let into his party wall [laughter.]

On Thursday, in further cross-examination, the plaintiff said he first felt the vibration in June, 1883. If his witnesses in their affidavits had said the nuisance commenced in April, 1884, they had made a mistake in the date. He had never heard any complaints that the liquor he kept was bad, and that his customers met with uncivil treatment; and it was a great shame for anything of the kind to be said, for it was not true. Witness's was a yearly tenancy.

Mr. EASON, a surveyor, said he examined the premises of both parties last year, and found five iron girders fixed in the party wall; the whole of the strain of the machinery was upon this wall, and it might be remedied by the building of a separate wall to receive the girders. He suggested this to Mr. Offor, the managing director of the defendant company. Witness testified to the shaking occasioned to the plaintiff's premises, and the constant noise. The Metropolitan Railway caused no annoyance to the plaintiff's premises, where the trains could not be heard. Witness made another inspection in February of this year, and found a number of wooden struts had been erected from the ground floor to the ceiling of the defendants' premises; their effect might have been to diffuse the vibration upon the party wall, but it had not diminished it. The vibration was not so perceptible in the plaintiff's premises as on the former occasion. In June six dynamos and two lathes were at work when witness called, and the noise and vibration were greater than before. The nuisance was so serious to the plaintiff's business that it must involve a reduction of rent to the extent of 15 per cent. The thickness of the party wall was 18in.

Other professional evidence was given to the same effect.

The case was not concluded when the Court rose.

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TELEGRAPHY AND THE SOUDAN CAMPAIGN.

The large and influential audience which assembled at the Society of Telegraph-Engineers one evening last week to hear Major-General WEBBER'S account of the Soudan telegraphs, of which he was Director during the recent campaign, were attracted probably more by the national importance of military telegraphy than by any special interest in the particular subject of the paper. The futile expedition for the relief of Khartoum is past and done with, its one redeeming feature likely to dwell in the memory of history being, not the intrepidity of the relieving party, but the stubborn endurance of the party to be relieved. That, however, is no fault of British soldiers or of their officers; and if the gloom of General Gordon's fate still casts its shadow over the glory of his attempted rescue, those men who took part in it—many of whom, besides General Webber himself, were present at Thursday's meeting—might proudly assert that whatever mortals could do under the conditions imposed was done, and that, although they failed, failure was due to no dilatoriness, mismanagement, or lack of heroic devotion on their parts.

The chief lesson of the campaign, indeed, was for the people of this country rather than for Telegraph Engineers, who have little to learn from it, or for military men, who are, or ought to be, agreed as regards its significance. The people of England are too apt to declare at the termination of every war, little or big, that this one is the last, that an era of peace will now most certainly ensue; and the people's representatives are far too ready to listen to such predictions—or rather to echo them, and to act accordingly. For ten or a dozen years past, however, there has been little interval for these foolish fancies to take effect; and if any Englishman survives who, rejecting the experience of his own country, confidently looked forward to a peaceful arbitrament of all future international disputes, and the impossibility of unprovoked hostilities between civilised communities, his credulity must have received a fatal stock at the beginning of this present week. Happily the delusions, bred of selfishness or hypocrisy, which infest the political atmosphere do not appear to have spread to the Military Telegraph Department. One speaker at the meeting we are referring to attributed the success of the Telegraphic Administration in the Soudanese and South African Expeditions in great part to the abundance of telegraph stores of the finest quality that money can buy or science invent. In view of current events, and those other eventualities looming in the not far distant future it is, perhaps, hardly necessary for us to urge with much vehemence the necessity for increasing the reserve stock of telegraph stores and apparatus, and for relaxing no efforts to increase and organise the body of trained telegraphists without whom the costliest appliances are but useless encumbrance.

An illustration of this fact was furnished in the Soudan campaign. It was known that a line of telegraphs existed in more or less perfect condition all along the Nile as far south as Khartoum, some fifteen hundred miles in length. Some of this, of course, had been destroyed; but to Wady Halfa, and partially to Dongola, a thousand miles south ot Cairo, communication was comparatively perfect—that is, perfect in an Egyptian sense. But such as it was it became practically useless directly the demands of a military campaign were made upon it, and chiefly for want of competent native hands to work the instruments, which were of a kind wholly unsuited for heavy traffic and fast working. A contingency of skilled telegraphists, none too large, had to be sent from England; and by good management not only was the line maintained and extended on the heels of the expedition, at all events till the desert track was reached, but a large amount of personal and press traffic was disposed of as well, with, as we all know, extraordinary dispatch. Nothing of this kind would have been possible but for an ample supply of picked men, who, besides being soldiers, were good telegraphists. A purely civilian staff would have been unsuitable for the circumstances, even could they have been enlisted, which is highly improbable. As a fact, it was made up partly of Royal Engineers, and partly of the Reserve Telegraph men belonging to the Post Office Rifle Volunteers.

It is much to the credit of the organisers of this last-named body that it now possesses a considerable force available for emergencies of the kind which arose during the years 1884-5. The Royal Engineers had already been taxed for the expedition in South Africa under Sir Charles Warren; and the later operations in the neighbourhood of Suakim required the equipment of virtually a third corps of telegraphists. We are not sure that the army proper could have responded to these demands, certainly not with such efficiency; for, after all, the only body of men who can be rightly called skilled telegraphists are the Postal Telegraph Volunteers, or such

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of the Royal Engineers who have been employed in telegraph offices of the Postal Telegraph Service. By wise foresight, and a happy coincidence of views, the postal authorities have almost from the very first acquisition of the telegraphs by the State lent willing help to the military departments, both in men and in the means of training telegraphists for purely warlike purposes. We could, perhaps, have wished this fact to have been more warmly acknowledged in General Webber's discourse, for we share Colonel Harrison's opinion that, next to excellency of equipment, the military telegraph owes its success in recent campaigns to the more than friendly co-operation of the State Telegraphs.

We noted with much satisfaction the uses to which the Telephone had been put during the expedition as a "sounder" in conjunction with vibrators. Where lines are of a very temporary, and, therefore, electrically speaking, of very imperfect description, we long ago predicted that this instrument would be of value for reading by sound where all other apparatus would fail; and we consider that a supply of telephones should form part of every military telegraph equipment. It should also never be without the means of restoring existing lines, which nowadays are met with at most unexpected and out-of-the way spots; and its line of extension should be of the lightest and most temporary kind when speed of erection is imperative. The wire lately erected in Bechuanaland at the rate of six miles a day was afterwards sold as a commercial concern. To follow or precede an invading army the speed of erection should be more nearly six miles an hour. Of course, lines of this description would not satisfy the requirements of the ubiquitous and unconscionable pressmen or the insatiable curiosity of the home newspapers. But the great thing to be done, and the only one worth consideration in the first instance, is to satisfy the requirements of the army and its generals; and for these a rapidly-moving telegraph line is the surest and best. Of course, there are points to which through communication by telegraph is unattainable; signalling by flag or by heliograph may then become almost a necessity. A closer connection, we think, ought to exist than obtains at present between these several systems of telegraphy in the army. But on this and other points relating to military telegraphs we hope shortly to publish some valuable opinions and suggestions by a competent authority on the subject.

HIGH-SPEED ENGINES AT THE INVENTORIES.

In our last impression we published a letter from Mr. P. W. Willans on this the subject of our article of the 6th inst. Mr. Willans' letter makes reference to it necessary at our hands.

First, we must disclaim all intention of withholding in the smallest degree the credit fairly won by certain makers of high-speed engines, and Mr. Willans will be amongst the first to admit the impossibility of referring in such an article to one or even to two engines in particular. We expressly avoided saying that all the high-speed engines had given trouble, and we did give credit for great improvement.

Secondly, Mr. Willans omitted to notice that cushioning has little effect of any kind on the strains to which we in particular referred by example. We dealt with the angular movement of the connecting-rod or its movement in a direction transverse to that of the piston, a direction of movement which throws an alternating transverse stress on the rod measurable by its inertia.

Thirdly, our last paragraph said "the improvements which have been made permit us to indulge in the hope of more." We therefore did not condemn high speed in principle, but the attempts to use high speeds without a proper attention to the proportions of all the parts of an engine intended to run at high speeds, and we gave one example of the heaviness of some of the strains. Incidents at the Exhibition proved the existence of these strains. That similar strains are borne by locomotives is perfectly true, but we may also remark that there are few engines so well proportioned or so thoroughly well made as the locomotives turned out by the leading locomotive engineers.

Moreover, our example was specially taken with a moderate high-speed, namely 250 revolutions per minute, at which, with a stroke of 18in., the connecting rod was forced to acquire an angular velocity of 196ft. per second in 0·06 of a second. If, however, we take the speed at 600 revolutions and a stroke as small as 6in., we get a speed of 157ft. per second impressed on the rod in only 0·025 of a second, which is worse for the rod than the example we had taken, or at least the rod would have to be stronger as against transverse strains. There is nothing impossible in making high-speed engines to run well, but great skill is necessary in designing such an engine, and nothing but good workmanship and material will carry out that design. As to the locomotive, we must also remark that high in character as is the design, workmanship, and material of these engines and their parts, they are never intentionally called upon to run more than about two hours at high speeds.

We are led to reply to Mr. Willans' letter because other readers may have limited their interpretation of our article in the same manner, and for the same reason it is desirable to say a word in reply to Mr. Crompton. It is quite unnecessary that we should say anything concerning engines which were not in the Inventions Exhibition electric lighting shed, and therefore unnecessary to reply to a considerable part of Mr. Crompton's letter. We fully agree with him in his choice of an engine, but we must remind him that in praise of a good engine it is not necessary to pervert the obvious meaning of our article or to attribute to us words which we did not use. We said not one word to lead any one to suppose that we attached any difficulty to the proper balancing or cushioning of an engine. We did not "pronounce insuperable" anything in connection with high-speed engines. We separated the questions relating to reciprocating parts and the employment of a cushion from the one illustration we used, and specifically mentioned this.

Again, we must remark that we did not specifically mention by name those engines which we did not intend should be included in the failures, for very obvious reasons; but we must also add that it would not please any one did we make particular reference to the nature of the failures referred to in general.

CORRESPONDENCE.

THE LAW OF THE DYNAMO MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As time did not permit of practically any discussion on the paper communicated by Prof. Silvanus Thompson last Saturday to the Physical Society on "The Law of the Electro-Magnet and the Law of the Dynamo Machine," I send the accompanying as my contribution to the discussion.

It consists of a letter written by me from London, on November 15th, 1878, to Prof. Perry, who was then in Japan, and his reply, consisting of a letter and the accompanying paper, dated January 16th, 1878, but which should obviously have been dated January 16th, 1879, Prof. Perry not having, I suppose, grown accustomed to dating with the new year. My letter and his reply are sent you *in original, without any*

alteration or addition whatever having been made since they were written.

Some parts of his paper are obviously intended for me alone, as, for example, when he laughs at my attempting to give the resistances to three places of decimals. I have refrained, however, from drawing my pen through such sentences in order that it may reach you in exactly the same state that it reached me. This paper, although it has never been published, is referred to and its contents briefly indicated in our contribution on Electro-Motors in No. 49 of Vol. XII. of the *Journal* of the Society of Telegraph-Engineers and Electricians, and reprinted in *The Electrician*, Vol. XI., page 330. In the paper, written by Prof. Perry at the commencement of 1879, the formula that has since been called Fröhlich's formula for a series dynamo is worked out, as well as the improvement in this formula (specially referred to by Prof. S. P. Thompson last Saturday) produced by the addition of a constant term for the effect of permanent magnetism. A term for the magnetisation of the iron core of the armature by the current passing round the armature coils was even introduced. That for every speed of a dynamo there is a *critical* value of the total resistance, and that practically no current can be obtained if the total resistance exceeds this value was also arrived at and dwelt on.

The laments made by Prof. Perry in his paper of 1879 on Dynamo-Electric Machines, and, in the letter accompanying it, that he had never seen a dynamo machine, and that no book or paper containing even a picture of a Gramme machine was available, are significant.—Very truly yours,

November 16th, 1885. W. E. AYRTON.

Original letter, written by me, Nov. 15th, 1878.

THE ELECTRIC LIGHT.

November the 15th,
98, Palace-gardens-terrace, W.

"My dear Perry: I want you, if you will, to take up the following question, at your earliest possible convenience (and that is why I send you a separate letter—to impress it on your memory)—what is the equation connecting the electromotive force of a magneto-electric machine with the internal and external resistances in circuit when the current generated is the current employed to magnetise the inducting electromagnets. Take as a special case, if you like, a Gramme machine, the formula must be such that when the external resistance is infinite the E.M.F. is nought, since in that case the current being nought there is no magnetism in the inducing magnets, &c. Schwendler believes it to be

$$E = K\left\{1 - \epsilon^{-\left(\frac{a}{r}\right)^2}\right\}$$

E = E.M.F.
K and a constants
ϵ = 2·71828
r = resistance

for a constant speed of revolution of the bobbins, but on my applying this formula to a number of experiments, I do not get agreement. I had to determine the constants by a graphical method of intersecting curves, since I found, on expanding in series, that even the fourth and higher powers could not be neglected, and this made an algebraical determination almost impossible.

I have gone through the complete work, both when "r" is the external resistance only, as well as when "r" was the total resistance in circuit—that is, included the resistance of the machine. I should have mentioned that in these experiments the light was not in circuit, but only a resistance coil of enormously thick wire, the resistance of which could be varied, so that there is no doubt about the accuracy of the measurements of resistance. The E.M.F. was calculated by multiplying the resistance by the current in absolute measure. I append some of the numbers to give you an idea of the experiments. It would be well, however, if you could determine a formula from general reasoning, and not merely a formula which satisfies the particular numbers obtained experimentally, since there may possibly be leakage when the external resistance is small, or when the E.M.F. is great; or as Sabine (partner of Sir Samuel Canning), to whom I have spoken on the subject, suggests there may be some inductive effect set up in each bobbin at the moment it is separated from the collecting brush. If you do not remember how these machines are made you will find accounts of all the different machines in the *Telegraph Journal* or in the *Engineer* or *Engineering*. *Remember no proper formula has yet been published, and it is much wanted.*—Yours sincerely, W. E. AYRTON.

Prof. John Perry.

P.S. It is possible it may be too late to post the newspaper (*Electrician*) by this post, but that will not in any way prevent your attacking the problem.

The Electrician I refer to is for October 26th, 1878, No. 23.

External resistance in Siemens' Units.	Internal resistance in Siemens' Units, that is, resistance of machine.	Sum R·	Current in Webers	E.M.F. in volts C × R.
5·195	0·645	5·850	6·22	34·70
5·095	0·645	5·740	6·85	37·50
4·620	0·675	5·295	9·342	47·17
4·345	0·635	4·980	10·94	51·96
3·930	0·670	4·600	13·32	58·43
3·555	0·645	4·200	15·54	62·25
3·205	0·660	3·865	17·71	65·28
2·840	0·655	3·495	20·01	66·70
2·490	0·635	3·125	22·60	67·35
2·125	0·635	2·760	25·72	67·70

The resistance of the machine varies slightly by heating, ∴ the numbers in column 2 are not quite all equal. I have allowed in calculating the last column for the fact that the resistances were measured in S. U., and not in ohms.

The above are obtained with magneto-electric machine A Siemens.

The following with magneto-electric machine C Gramme's.
Mean internal or machine resistance 1·16 S.

External resistance. S. U.	E.M.F. in volts for mean speed 867·5 revolutions per minute.
5·832	64·59
5·085	66·39
4·345	68·89
3·535	72·08
1·320	73·97"

Tamiēke Asabu, Tokio, Japan,
16th January, 1878.

"Dear Ayrton: With this you will, I hope, get my ideas on magneto-electric machines. But it is awful to have to write on such a subject, not having an example to look at.—Yours truly, JOHN PERRY."

DYNAMO ELECTRIC MACHINES.

Our object is to get a rational formula connecting the electromotive force and resistance of dynamo-electric machines. We shall suppose that at all speeds and with all resistances with which we have to deal, the internal resistance of the machine is constant; that is, that there are no sparks at the brushes.

We shall also suppose that when the bobbin is rotating uniformly the resultant electro-magnetic force, and the directions of the lines of force at any point near the bobbin remain constant. It is quite evident that this is the condition which holds with more and more truth as we make the separate coils of our rotating bobbins greater and greater in number, and as our resulting current is more and more constant. Evidently this means perfect symmetry of the bobbin about any place through its axis.

Our theory depends on the following facts; first, the shape of the field of force about an electro-magnet and in the neighbourhood of pieces of soft iron under its influence is independent of the strength of the current; second, the

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resultant force at every point in the field about an electro-magnet is $\frac{aC}{b+C}$, where a and b are constants and C is the current.

The first fact we have roughly proved by means of iron filings on sheets of paper. We cannot imagine that it is strictly true for all currents and all magnets, but we think it true enough within the moderate ranges in which our calculations are to be employed. We are now finding accurately what changes do occur in the shape of the lines of force about an electro-magnet when the current is altered. And here let us remark that this iron-filing method, although sufficiently accurate when large electro-magnets are in question, cannot be regarded as even giving approximately correct results when employed to give shape of a weak field. We have known some experimenters use a thick coating of iron filings in getting the field about a wire conveying a weak current of electricity. We would ask them if the force at a point in the field about a magnet is not somewhat influenced by a string of nails leading to the pole of the magnet, and if such a string of nails does not materially influence the shape of all the rest of the field.

For the second fact, until our own experiments are completed, we must depend upon the experiments of Waltenhofen and others described in Wiedemann's "Galvanismus," and from these it may be shown that

$$m = \frac{aC}{b+C} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where m is the magnetic moment, C the current, a and b constants. This is only an empirical formula, but its suitability strikes one at once. Thus we see that it satisfies the known conditions for weak currents, since with weak currents it is known that the magnetisation is proportional to the current. Also as the current gets greater and greater, the magnetisation approaches a limit, the point of saturation.

Thus, taking at random some of Waltenhofen's results given in the following table, where m is the magnetic moment and C is the magnetising current observed :—

m.	C.	Calculated. m.
1·37	2	1·87
2·79	4	2·74
3·31	6	3·24
3·66	8	3·56
3·76	10	3·78
4·11	15	4·14

The third column is seen to be sufficiently near the observed values. The third column is calculated from

$$m = \frac{5{\cdot}077\,C}{3{\cdot}408 + C},$$

whose constants we have determined by method of least squares.

It will be found that in this and every other case the empirical formula

$$m = \frac{aC}{b+C}$$

is more satisfactory than the formula

$$m \propto \tan^{-1} aC$$

given by the experimenters. (This is not the only reason why we have chosen this formula. Our best reason is that the trigonometrical formula, when applied in the following way, leads to a result which is rather difficult of application, namely, that in a dynamo electric machine if E is E.M.F. in circuit and C is current, then

$$E = a \tan^{-1} (b \tan^{-1} cC) + d \tan^{-1} eC$$

Now, as our empirical formula is as good or rather better than the trigonometrical one we use it.)

Given a coil of wire surrounding an electro-magnet, if we know the current in the coil we know the field of force which produces magnetisation. If the iron were spherical or ellipsoidal we could determine accurately the magnetisation and the field of force due to the magnetising current and to the magnetisation, on the assumption that the coefficient of induction is constant. But it is well known that this is only true when the current is comparatively weak; whereas, more towards the point of saturation, the only relation which we can take between the magnetising force X and the magnetisation A at any point in a mass of soft iron is

not $$A = KX$$

but $$A = M - \frac{N}{X^2}.$$

It will be at once seen that although X satisfies the characteristic equation $\nabla^2 X = 0$, A does not satisfy it, and we see, therefore, that even to a sphere we cannot apply the results of Poisson's theory. According to this theory, if we alter the current which produces magnetisation in a sphere of soft iron, we alter the resultant force at any point in the same ratio, but the shape of the lines of force remains unaltered ; but this is not the case for a soft iron core of any other shape, nor is it true for a spherical core if A is not proportional to X.

Our two assumptions are therefore based on a limited number of experiments, and we have been surprised to find that of available information on the subject there is so very little.

When the bobbin is rotating uniformly, since we have assumed its perfect symmetry, the direction of the lines of force at any fixed point is, by our first assumption independent of the current, being simply a function of the position of the point, and the part of the resultant force at the point due to the electro-magnet alone is

$$\frac{aC}{b+C}.$$

Now, it is this force which, with the currents circulating in the bobbin, magnetises the core of the rotating part, and according to the same law the total resultant force at any fixed point ought to be expressed in the form

$$e + cC + \frac{aC}{b+C} + \frac{a''C}{b''+C}$$

where e, c, a, b, a'', b'' are constants, for it evidently consists of the following terms :—

1° A small term e due to permanent magnetism of magnet, or core, or the earth, or &c.

2° A small term cC due to current in the wire. (Remember that C is constant if the separate coils of the bobbin are infinite in number.)

3° A term $\frac{aC}{b+C}$ due to mag. of electro-magnet.

4° A term $\dfrac{A\dfrac{a'C}{b'+C}}{B+\dfrac{a'C}{b'+C}}$ or $\frac{a''C}{b''+C}$ due to magnetiz. of core,

which is itself produced by magnetisation of the outer magnet. (Easy to show this term very nearly prop. to C.)

It is evident also that any other terms will be of this shape $\frac{aC}{b+C}$, produced by magnetisation of bobbin's core by the current round bobbin, &c.

The electromotive force in an *element* of wire of the bobbin is therefore proportional to

$$n\left(e + cC + \frac{aC}{b+C} + \frac{a''C}{b''+C}\right)f$$

when n is number of revolutions per minute and f is a function of the *position* of the element, which is the same for all elements reaching that position. (This proportionately to n is only true if iron is truly *soft.*)

Hence, the total E.M.F. of the circuit, being the sum of all such terms as this, may be put (leave out term n since it is constant in the problem proposed to J. P. by W. E. A.)

$$E = p + qC + \Sigma \frac{aC}{b+C}$$

where p, q, a, b, &c., are constants. Now since, until iron is

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getting saturated, C is less than b in all the terms, we may use the expansion

$$\frac{aC}{b+C} = a\left(\frac{C}{b} - \frac{C^2}{b^2} + \frac{C^3}{b^3} - \&c.\right).$$

So that so long as C is less than the various values of b we may use only a few terms of the right hand side of the following equation.

$$E = a' + b'C - c'C^2 + d'C^3 - e'C^4 + \&c.,$$

for we see that c', d', e' are in descending order of magnitude. Now, we are prepared to show that for the known dynamo-electric machines this is the case. If quite true, they mean that saturation is not approached, because this would mean that $C > b$.

In dynamo electric machines, when C is not too small, the constant term a' is insignificant (it is due to permanent magnetic field). But in neglecting it, as we shall do, we must not use our subsequent formulæ for currents which are exceedingly small.

Since, if r is total resistance of circuit $E = Cr$

$$r = \frac{a'}{C} + b' - c'C + d'C^2 - \&c. \quad . \quad . \quad . \quad (I)$$

Although in dynamo-electric machine the first term is insignificant, its importance is shown when we assume that r gets greater and greater, and $\therefore$ C smaller and smaller. We would infer from the formulæ that when the current gets very weak, if there is no permanent magnetic field due to earth, or other perm. magnet, then, since $E = b'C$ and $E = rC$, cannot both be true at same time unless $b' = r$, the current must diminish to zero or else increase.

I should think that if r is greater than b' the current would diminish to zero, the rotation of bobbin being maintained constant, but if r is less than b' then the current will continually increase until some point is reached for which

$$E = b'C + c'C^2 + \&c.$$

In fact, therefore, it would seem that if there is no permanent magnetic field, there is a limiting value for r beyond which we cannot get a current.

To illustrate this part of subject, suppose we use *no* soft iron, merely coils of wire in the whole apparatus. Then the strength of field due to C is known to be proportional to C, and if we have also a permanent field*

$$E = n(aC + b) = A + BC \text{ say,}$$

but $\quad E = rC$, if r is total resistance of circuit,

$$\therefore Cr = A + BC$$

(1) . . $r = \frac{A}{C} + B$ (C very small implies r very great.)

(2) . . $E = \frac{Ar}{r - B}$

Now, what is the meaning of $r = B$ in (2)? We cannot say, except that it might, we expect, be shown in some way to be impossible. A very interesting experiment might be made with a dynamo electric machine using *no* soft iron and having the internal resistance very small, reduce the total resistance more and more. In the absence of experiment we can only say that, if the constant term due to perm. mag. be supposed $= 0$, then there seems to be only one resistance which will enable the equation to be satisfied for a given number of revolutions. That is, if speed is constant, if $r > B$, then current will diminish to zero. If $r < B$, then current will increase to infinity (!!). Possibly the results of experiment would enable us to understand this better, but I do think that some startling result would be derived.

In the absence of such experiments, and since also we have no experiments to appeal to with regard to the gen. formula for magneto electric machines ( ) when the currents are very weak, we must ask that this formula (which is merely a reduction of $E = AC + \Sigma\frac{aC}{b+C}$) where the constant term is left out, be only applied to the usual cases of magneto electric machines, the resistance not being very great. And the modified formula

$$E = b'C - c'C^2 + d'C^3$$

be only applied to cases where the current is neither too great nor too small. We have no doubt, however, that observation will confirm the general formula (I).

Thus to take the only observations at present available, namely, some observations . . . . . . Sent by Ayrton to Perry.

Ayrton to make other observations and try if they fit the formula, also to try if, when resistance is *very* great, our theory, given above, is right, then he can modify the above statements.

SIEMENS' MACHINE A.

External Resistance in Siemens' Units.	Internal Resistance in Siemens' Units.*	Sum r.	C Current in Webers.	E.M.F. in volts. cr.	$\frac{1}{r}$
5·195	0·645	5·850	6·22	34·70	·1709
5·095	0·645	5·740	6·85	37·50	·1742
4·620	0·675	5·295	9·34	47·17	·1888
4·345	0·635	4·980	10·94	51·96	·2004
3·930	0·670	4·600	13·32	58·43	·2174
3·555	0·645	4·200	15·54	62·25	·2381
3·205	0·660	3·865	17·71	65·28	·2587
2·840	0·655	3·495	20·01	66·70	·2862
2·490	0·635	3·125	22·60	67·35	·3200
2·125	0·635	2·760	25·72	67·70	·3623

* The internal resistance varies slightly by heating.

GRAMME'S MACHINE C.

Ext. Resistance S.U.	E.M.F. in Volts for Mean Speed of 867·5 revol.
5·832	64·59
5·085	66·39
4·345	68·89
3·535	72·08
1·320	73·97

Mean internal resistance 1·16 S.U.

The observations from Gramme's machine do not satisfy the linear law $r = a - bC$, as may be seen by plotting on squared paper (plot both for Siemens and Gramme to show the difference). But I am sure that Gramme would satisfy

$$r = a - bC + dC^2$$

I have not enough observations to try this.

We have plotted the observed values of r and c for Siemens' machine, the values of r and c being co-ordinates of points, and we find that these points all lie nearly in a straight line (perfectly straight for the first six values of C), and, therefore, for such currents and resistances as the observations give the higher terms disappear. So that the general formula

$$E = A + BC + \Sigma\frac{aC}{b+C}$$

becomes $\quad E = aC - bC^2$

since $\quad r = a - bC.$

Putting this in the shape $\frac{r}{a} + \frac{b}{a}C = 1,$

or $\quad a'r + b'C = 1,$

and using methods of least squares, that is getting a' and b' from the two equations

$$\left|\begin{array}{l} a'\Sigma r^2 + b'\Sigma rC = \Sigma r \\ a'\Sigma rC + b'\Sigma C^2 = \Sigma C \end{array}\right|$$

we find as our result that

$$r = 6·798 - 0·1622\,C.$$

* Truly, since we must imagine no change in shape of lines of force, we must imagine, 1st, that a very thin bar of soft iron placed in the outer coil and magnetised with a weak current. Now, imagine that for all future time this soft iron becomes *hard steel*, not changing its magnetisation. This is what we must suppose producing the above constant term.

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Applying this to the values of C given in original table we get the following values of r:—

Observed. r	Calculated. r	Difference.
5·850	5·789	−0·061
5·740	5·687	− ·053
5·295	5·282	− ·013
4·980	5·023	+0·043
4·600	4·637	+ ·037
4·200	4·277	+ ·077
3·865	3·925	+ ·060
3·495	3·553	+ ·058
3·125	3·132	+ ·007
2·760	2·625	− ·135

(I am sure these differences are well within limits of your measurement. Three places of decimals, indeed. I don't believe it! Coil was heating?)

(In getting out the above formula, &c., Perry worked a week doing "*sums*," as Milne puts it. Such columns of least squares. Bottomley's tables give fearful results. Such reams of paper have been used!)

Now, what I see, judging from the very meagre information at hand (I cannot get a description of Gramme's machine. Shida has three volumes of *Telegraphic Journal* in the country; two volumes of *Engineering* and *Engineer*, which may possibly speak of Gramme, are out of the library. I have only Brittle's paper of Institute of Civil Engineers, and short sketches of a few magneto-electric machines, but not one of Gramme), is this, that Siemens' machine is nothing like so good as Gramme's. Gramme has his iron more saturated, ∴ in a more efficient state. He can use ever so much more speed, and therefore he can make it smaller.

Since (Siemens) the observations of r and C are nearly in a straight line on squared paper, but *not quite*, I assumed

$$E = aC + bC^2 + dC^3$$

or

$$r = a + bC + dC^2$$

and tried to find a, b, d by method of least squares. But the work is awfully long, and after wasting two nights at it, and being wrong twice, I leave it to you to do.

You can make lots of observations on lots of machines, and argue on them on the above lines.

Always choose the equation

$$r = a - bC + dC^2 \quad . \; . \; . \; . \; . \; . \; . \; . \quad (1)$$

or

$$r = a - bC \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2)$$

or

$$r = \frac{a}{C} + b + \Sigma \frac{e}{f + C} \quad . \; . \; . \; . \; . \; . \quad (3)$$

If (2) suffices (tested by squared paper) then there is little *saturation* in the machine. If (1) suffices there is more saturation, but still not very much. If neither suffices then we need to assume $r = \Sigma \frac{a}{b+c}$, or (3).

With an
sheets of paper and iron filings the true
various intensities of current. Especially
horse-shoe (plane of paper in above
Also get a sphere of soft iron covered with (*)
wire packed closely and in parallels of latitude.
in a diametral plane for currents of all
possible get at a number of points the st
field by a small vibrating magnet or to
with the horse-shoe magnet.

Compare results with sphere with the results of Poisson's theory, and consult Clerk Maxwell's book on current function ϕ, &c., &c. You will find here matter for a very good paper, and the experiments will not be difficult. You may also try an ellipsoid of soft iron, but calculation is more difficult.

Is it true that the field remains nearly constant in shape? Does the magnetic moment follow the law $m = \frac{aC}{b + C}$, where C is current, a and b constants.

You ought to try above experiments with soft iron, then use same coils on equal spheres of steel of various hardnesses, &c., &c. This is really the scientific way of proceeding in experiments on magnetism. Use *Spheres*. Your coils you may make in the shape of two rigid hemispherical shells, so that you may remove one sphere and place on another.

Especially try up to SATURATION *points.*

* [The manuscript here is torn, and a figure of a small magnet has been omitted.—ED.]

A PHENOMENON OF CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The correspondence of Mr. E. A. Williams and Mr. J. T. Sprague on this subject recalls to mind some investigations on this subject by Mr. Rankin Kennedy, of Glasgow, which I, as a student, had an opportunity of witnessing.

Mr. Kennedy took a large induction coil, passed an alternating current through the primary wire of this from a dynamo; the same current also passed through and fully lighted up about a dozen incandescent lamps in parallel, so that any variation in the strength of the current was visible and perfectly apparent on the brilliancy of the lamps.

The core of the coil, which had been withdrawn before switching on the current, was first gradually entered into the coil, and as it entered the current became less and less in the primary circuit, which effect was nicely observed in the decrease of the lights from the lamps, they finally becoming quite a dull red. During this experiment the secondary circuit was not closed.

The first experiment showed clearly that the effect of the iron core being introduced into the coil was to diminish the primary current very considerably.

In the next experiment the core was withdrawn when current rose to its former strength as seen on the lamps, and now a lamp was connected to the secondary circuit of the coil, and although the large current was alternating in the primary this lamp in the secondary was barely a visible red light. On introducing the core into the coil now, the primary current fell off again, but not so much as before, while at the same time the lamp in the secondary became brighter, showing that while the introduction of the iron core reduced the primary current it increased the secondary current.

In the next experiment the one lamp in the secondary circuit was switched out while the core was in the coil (and the lamps in the primary circuit consequently very dull). The consequence of switching out this lamp in the secondary circuit was most remarkable, the lamps in the primary circuit became duller still; on switching on lamps one by one in parallel into the secondary circuit the lamps in the primary became brighter and brighter, showing that the primary current increased as the secondary increased, and *vice versâ*; in fact, it was shown that by short-circuiting the secondary circuit the current in the primary rose from 8 to a value of 12 amperes.

It was shown that as the resistance of the secondary circuit decreased the current in the primary increased up to a certain point, at which the primary current ceased to rise, and the E.M.F. in the secondary circuit commenced to fall, and continued to fall until completely short-circuited. This account of Mr. Kennedy's class experiments may throw some light on the matter in discussion, and may be of interest to many as very instructive and beautiful experiments. They were made about three years ago, and it was expected that a full account of the investigations would have been published by the author of them; this has not yet been done, and hence I venture to contribute this from my notes.—Yours, &c.,

Glasgow, 7th Nov., 1885. AN ELECTRICAL STUDENT.

THE VALVE TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly grant me a little space in which to correct a few inaccuracies which have crept into your description of the instrument which is described on page 9 of your current issue as my invention.

The instrument which you figure is not the invention of myself alone; it was devised jointly by Mr. Philip Jolin, of

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Bristol, and myself, under my patent of 1882, and it is fully described in our joint specification for valve telephones, in which specification, however, many forms of instrument are described beside the particular one figured in your cut. In that form of instrument there is a mouthpiece or funnel affixed to the lower end of an open tube, which is supported in a substantial bracket, and leads the speaker's voice direct to electric mechanism at the top. This mechanism is extremely simple, and in the form of instrument in question consists only of a ball resting on three points let into the top of the tube. The ball shown in your engraving consists of an alloy or composition of which the essential ingredients are copper and selenium, or similar materials, and, as your readers will observe in your cut, the lower side of the ball, which makes contact with the three pins, is polished bright. A light wire or stay is carried through the ball and is formed into a loop at the top. The majority of our instruments in use are of this type; but, as our specifications show, other forms of valve beside the ball can be similarly used to receive *the direct impact* of the speaker's voice, and we have laid no formal claim in our specifications to the particular composition or material which we employ in any of these instruments, seeing that almost any of the substances of which a good microphone can be made can be employed in one or other of our various forms. We have tried coke and carbon, but find the articulation less crisp than with our composition.

With the particular forms used by Mr. Irish subsequently to our invention we have nothing to do, and are willing to give him every credit for the undoubted ingenuity which he possesses; but we must kindly be permitted to doubt whether he or any other person has invented a simpler arrangement than ours, or one which possesses a clearer articulation.

You further say that it is open to question whether it is really the case that we do not use a diaphragm. Will you kindly allow me to remove that doubt; we do not. Our tube is open from end to end, so that the speaker's voice goes direct up the tube to the electric valve at the top.—Yours, &c.,

November 14th, 1885. SILVANUS P. THOMPSON.

HIGH-SPEED ENGINES AT THE INVENTORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have read with much interest your leading article on the subject of high-speed engines, and Mr. Willans' reply thereto in your last issue. We agree with Mr. Willans that your article contains a number of statements which are not borne out by actual practice in the use of these high-speed engines. Your remarks seem to be based on the indifferent performance of those high-speed engines which were tested at the Inventions Exhibition, many of them for the first time, and certainly do not apply to the engines made by Mr. Willans himself, and probably also to those of more than one other maker. Anyone reading your article would be led to believe that the questions of balancing and cushioning high-speed engines, by which we mean those running at speeds varying from 300 to 600 revs. per min. are so great as to be practically insuperable. How, then, sir, do you account for the fact that the whole of the electric lighting machinery of the ships in Her Majesty's navy are driven by such high-speed engines running at speeds varying from 380 to 450 revs. per min., and that Her Majesty's engineers are in every way satisfied with them?

As a matter of fact the difficulties which you pronounce insuperable have been surmounted by Mr. Willans himself, as well as by others. We ourselves feel the utmost confidence in supplying to our customers dynamo machines driven directly by Willans' engines at speeds not exceeding 550 revs. We mention this limit, because we think it is only fair that it should here be publicly stated that one of our dynamos, driven by a Willans' engine at this speed of 550 revs., supplied the current for lighting Old London during the whole of the Exhibition, that it never stopped or was eased down for one moment, that it was never necessary to use the spare set, and that the engine and dynamo both are absolutely as good as the day they left our respective workshops, and that we are certain that this result has not been excelled, if equalled, by any set of high-speed dynamos coupled to low-speed engines and worked for an equally long period.

We hope to have the pleasure of laying before you the results of a series of a trials made with large dynamos driven direct by Mr. Willans' latest form of compound engine, which have yielded results, as far as we are aware, the most economical yet attained in the return of useful electrical energy at the terminals of the dynamo as compared with the coal used in the boiler.—Yours, &c, R. E. CROMPTON AND CO.

ON THE AMOUNT OF LIGHT OBTAINED BY INCANDESCENT CARBON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If an electric current is passed through an incandescent lamp the effect of the curent will manifest itself by the heat generated in the carbon.

As long as the temperature is low no visible rays are emitted, but with the gradual rise of temperature luminous rays are given out, which soon increase in intensity. The total amount of energy which is then expended by the carbon may be considered as consisting of both heat and light radiations.

As the amount of light obtained from the incandescent carbon increases with the temperature of the same, it appears as if a certain fixed relation might exist between the light and the total amount of energy radiated from the carbon.

Now, the incandescent lamp offers to us one of the means of investigating this question, because the total amount of radiated energy must be equal to the electrical work consumed in the lamp, provided that no losses of electric energy occur.

If, then, we measure the amount of light obtained from the incandescent carbon, from the first stages up to the highest temperatures, and at the same time note the corresponding value of the current, as well as the difference of potential at the terminals of the lamp, the product of the two last, now generally called the number of watts, will give us the energy corresponding to the light emitted.

By comparing a large number of measurements made on different lamps in reference to this question, I find that the following relation appears approximately correct:—

The amount of light obtained from an incandescent lamp increases with the third power of the number of watts required.

Or, if we express this relation in a more general way, in which it seems more likely to be true, we may say:—

The amount of light obtained from carbon at different stages of incandescence increases as the third power of the total amount of energy radiated from the carbon.

We may express this relation in its first form by the following formula:—

If λ is the amount of light emitted, generally measured in standard candles,

V A the number of watts required for producing the light λ,

then $\frac{(V\,A)^3}{\lambda} = K$, in which K has a constant value peculiar to every lamp.

Before proceeding any further, it may be as well to notice one useful practical application of this formula. It is often desirable to know at what candle-power a certain incandescent lamp will work with a specified expenditure of energy, say with n watts per candle; in this case we have $V\,A = n\,\lambda$, and by substituting this value of V A in the equation given above we get at the candle-power required, $\lambda = \sqrt{\frac{K}{n^3}}$. The constant K can be determined by making one single measurement at any arbitrary candle-power. This rule of course only applies within those limits within which the general formula is correct, as will be explained later on.

The formula given above may be put into a different shape by expressing the energy in terms of the current (C) and resistance (R); we then have $\frac{(C^2\,R)^3}{\lambda} = K$.

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Now, within certain limits the resistance of a lamp changes very slightly, and may therefore be considered as constant. It then appears, that within these limits the amount of light varies as the sixth power of the current, a fact which has been observed before by Mr. Preece and by Mr. Kittler.

The value of K, which I have hitherto considered as constant, is only so up to a certain state of incandescence, and is then subject to variations, which seem to depend on the style of the lamp.

At first the value of K is slightly higher, but soon reaches a minimum ; it then remains practically constant up to a candle-power which is largely in excess of the normal candle-power. The slight decrease at low candle-power does not always occur, and may be due to uncertainties in the measurement of light, when the carbon is of a reddish colour. But the growing increase in the values of K at the highest state of incandescence must be due to other causes. We must either suppose that the relation between energy and light at the highest state of incandescence of carbon has a form differing from the one which I have stated above, or that losses of electric energy occur inside of the lamp. In this last case the measured value of V A would be in excess of the energy which is radiated from the carbon, thereby producing an increase in the value of K.

From observations on incandescent lamps I am inclined to think that such losses of electric energy actually occur, and that they grow with the increase of the temperature of the carbon and with the difference of potential between the two terminals of the lamp being at the same time dependent on the state of the vacuum. The experiments made by Mr. Preece on a model suggested by Mr. Edison quite confirm this view. I have therefore preferred to state the apparent relation between light and radiated energy in its more general form, irrespective of the incandescent lamp.

Although the measurements which are in my possession have induced me to publish these remarks, it would be interesting to see the same verified or corrected by the results which others may have obtained by accurate measurements.

And, furthermore, it appears desirable that the relation between the radiated energy and the light emitted by incandescent carbon at different temperatures should be observed, independent of the electrical energy consumed.—Yours, &c.,

ALEXANDER BERNSTEIN.

HEDGES' AUTOMATIC AND FUSIBLE CUT-OUTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the supplement of *The Electrician* of November the 6th you were good enough to give a description of some of Mr.

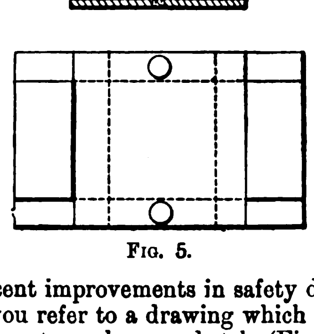

FIG. 5.

Hedges' most recent improvements in safety devices which we exhibited. As you refer to a drawing which does not appear, we have the honour to enclose a sketch (Fig. 5) of the new mica foils described in your article. These fuses can be relied on to melt within 10 per cent. of the current marked thereon ; thus a fuse marked 100 amperes will be melted with a current between 95 and 105. Carrying out a suggestion which appeared in your columns some time ago, we propose making them still more sensitive, so that by inserting a Hedges cut-out in the circuit of an amperemeter the instrument can be checked by noting the current registered when the fuse is melted. As accurately cut foil melts with a maximum deviation of 2 per cent., it will be possible to keep all instruments within this limit of error without the trouble of calibrating.—Yours, &c.,

J. BURGIN, Secretary,
Globe Electrical and Engineering Company.

20, Dartmouth-street, Westminster, S.W.

THEORY AND PRACTICE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The justly-appreciative article on Mr. Williams's "Manual of the Telegraph" which appears in *The Electrician* contains the remark that "few men can be found to attempt the practical work," and refers to the enormous disproportion in the number of theoretical and practical men, although, as the writer observes, it frequently happens that "theory says so and so will happen if so and so be done. Practice says so and so cannot be done, and therefore the theoretical so and so cannot happen." In my experience I have even had this position reversed, theory asserting that so and so could not be done, practice proving that it could be done. I never forget my personal experiences of the Postal Telegraph Department, and when on one occasion Sir William Thomson and Prof. Fleeming Jenkin were sent here to see me about my telegraph instrument. Whilst I was describing the operation of printing the signs on the paper coil Mr. Jenkin impetuously asserted that it would be impossible to hold the paper and to release it on printing each sign. I assured him that it could be done by utilising the same lever that operated the printing to clamp the paper. He immediately declared this to be quite impossible, and, appealing to Sir William, repeated that it would be a mathematical impossibility. (He had left out of his calculation the thickness of the sheet of paper.)

Uncovering an instrument, I requested Mr. Jenkin to start it, and to watch the simple arrangement which sufficed to clamp the paper and to print sixteen hundred definite and clear signs in a minute. The mathematician bowed to the mechanician, and there the matter ended, and there it still remains.—Yours, &c.,

RICHARD HERRING.

27, St. Mary's-road, Canonbury,
November 18th, 1885.

LITERATURE.

Electrolysis: a Practical Treatise on Nickeling, Coppering, Gilding, Silvering, the Refining of Metals, and Treatment of Ores by means of Electricity. By HIPPOLYTE FONTAINE. Translated by J. A. BERLY. Thirty-four illustrations. [E. and F. N. Spon.]

The English student can hardly expect to improve upon the works of Dr. Gore in the subjects connected with electro-disposition, but they will find in this book of Mr. Fontaine's some supplementary information in the introductory chapters which is interesting and useful; in fact, it is this supplementary value which renders the work at all serviceable. M. Fontaine's experience and scientific attainments in this special direction are not conspicuous, but he possesses a certain ability to put what he knows in a simple manner. It must be mentioned that the work was not written for an English public, but to fill a gap in French technical literature, which boasts "only two practical treatises on electrolysis," and these are antiquated. Under these circumstances we congratulate our French brethren upon having obtained a compilation, the practical part of which is extracted chiefly from English authorities. The preface, while giving us these facts as to French literature, mentions six well-known books in English and seven in German, showing there is no dearth of treatises on electrolysis in those countries. The introductory portion of the book occupies the first hundred pages, and deals with preliminary notions on units, electrolytic laws, work absorbed in electrolysis, tabular data, batteries, and dynamos in seven chapters. We are sorry to be unable to give any credit to the tabular data, and think that a book issued in the year of grace 1885 should in its electro-deposition take cognisance of Lord Rayleigh's determination as regards silver, from which such figures take a new and more accurate start. The fact that the tables given contain figures based upon old experi-

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ments seems to indicate that neither author nor translator are familiar with the most recent work. Then, again, the chapter on batteries is altogether deficient. It is merely a descriptive list of different cells, almost without a word to indicate to the reader which is the best to use, or why it is the best. The chapter on "Work Absorbed" is far and away the best of this introductory portion, and indeed may be said to be excellent. Coming now to the practical portion, we find it contains a very fair *resumé* of what has been published in previous book upon the subject, and the best feature of this part is that the authorities for the information are freely given. We, however, prefer the authorities to the compilation. The translation would have been better by an Englishman who knew the French language school-boy fashion rather than by a Frenchman who knows English school-boy fashion.

PHYSICAL SOCIETY—November, 1885.

Mr. G. M. WHIPPLE described and demonstrated experimentally the process of testing thermometers at and near the melting-point of mercury as carried on at Kew. About 20lb. of mercury are poured into a wooden bowl and frozen by carbonic acid, snow, and ether ; the mercury is stirred with a wooden stirrer, and the snow is added till the experimenter feels by the resistance to stirring that the mercury is freezing. The stirring is continued for some time, which causes the mercury to become granular instead of a solid mass. The thermometers are then inserted together with a standard and compressed. About 100 mercury or 40 spirit thermometers can be thus examined in half an hour, using about 200 gallons of carbonic acid gas composed sufficiently to form the snow. The bowl, ether, and mercury are cooled first to 10°C. by an ordinary freezing mixture. The average correction at the melting point of mercury is now less than 1°F. ; when the process was introduced in 1872 it amounted to 5°, but has steadily decreased.

"On the Electromotive Force of Certain Tin Cells," by Mr. E. T. Herroun. Mr. Herroun has examined the electromotive forces of cells in which tin in a solution of its salts was opposed to copper, cadmium, and zinc in solutions of their corresponding salts, the solutions being of equal molecular strengths. The salts used were sulphates, chlorides, and iodides, and the cells were of the ordinary Daniell form, with a porous vessel. To prevent the formation of basic salts it was necessary to add a little free acid to the solution of the tin salt, and to counterbalance the influence of this acid upon the E.M.F. as far as possible an equal proportion of free acid was added to the other solution.

Prof. G. MINCHIN pointed out the importance of performing these and similar experiments upon tin in the dark, as by allowing light to fall upon the tin plate a considerable photo-electric effect would be obtained. Prof. Fleming insisted upon the great importance of temperature corrections in all experiments upon two-fluid cells.

"On the Law of the Electro-magnet and the Law of the Dynamo," by Prof. S. P. Thompson. It cannot be said up to now that any particular law has been generally accepted giving the relation between the current in the coils of an electro-magnet and the magnetism induced by it in the core. Many empirical formulæ have been given, most of which are entirely wrong. One, however, recently enunciated by Fröhlich gives a relation which agrees very closely with observed values. This formula is $m = \frac{i}{a + b\,i}$, where m is the magnetic moment of the core, i the current, and a and b constants depending upon the geometrical form of the magnet and the nature and previous history of the iron core. Fröhlich obtained this relation by experimenting with a series dynamo. It is purely empirical, but since it agrees so well with the facts as to give values for the magnetism of the core agreeing almost within experimental error with those observed, there is great probability of some law being at its base. And this law Prof. Thompson believes to be one that was stated years ago by Lamont—"The magnetic permeability varies with the quantity of magnetism the iron is capable of taking up." This may be expressed by the formula

$$\frac{d\,m}{d\,i} = k\,(\mathrm{M} - m).$$

Integrating which and expanding $e^{-k\,i}$ in powers of i

$$m = \mathrm{M}\,k\,i\left\{1 - \frac{k\,i}{2} + \frac{k^2\,i^2}{6} \ldots\right\}$$

Expanding Fröhlich's equation in powers of i we get

$$m = \frac{i}{a}\left\{1 - \frac{b\,i}{a} + \frac{b^2\,i^2}{a^2} + \ldots\ldots\right\}$$

If it is not great these expressions will coincide in form very closely, and the results lead Prof. Thompson to accept Lamont's expression as being that of a real physical law.

Prof. PERRY suggested that Lamont's law gave good results, from its being an approximation to Weber's theory of induced magnetism ; but Prof. THOMPSON maintain that it represented observed facts better than that theory, which, as developed by Maxwell, shows a decided discontinuity in the process of magnetisation not actually observed. Prof. FLEMING remarked upon the similarity of Fröhlich's expression to that for the current through a voltameter, the part $a + bi$ corresponding to the apparent resistance which may be considered in this case as the resistance to magnetisation of the core-air circuit, and which, like that of the voltameter, varies with the current.

COMPANIES' MEETINGS.

The West India and Panama Telegraph Company (Limited).

The seventeenth ordinary general meeting of the members of this Company was held at the City Terminus Hotel, Cannon-street, on the 18th inst. Mr. C. W. Earle presided.

The SECRETARY (Mr. R. T. Brown) read the notice convening the meeting and the minutes of the last meeting, which were confirmed. The report, which has been published in *The Electrician*, was taken as read.

The CHAIRMAN said: Gentlemen, the report, I think, is the shortest we have ever published, and the reason of that is that there has been very little of an eventful nature in the half year to refer to, and the accounts themselves practically tell the whole story. My remarks will also be very short, for the same reason. The balance of revenue over expenditure is almost the best we have ever had as yet. It is £1,190 in excess of that of the corresponding half year of 1884; and with the exception of one previous instance, in 1878, when it was about £1,000 better than now—which was an exceptional time, owing to certain windfalls we had in the chartering of our ships, and so on—the past six months has been the best first half year we have had to report on. Upon the expenditure side of the accounts I have very little to say. The respective amounts of the different items are very much the same as they were before. I have had a letter from one shareholder remarking upon the expenses of the ships in harbour. I presume that that gentleman thinks that these ships of ours go into harbour in the way you would lay up a collier. The fact is that, whether the ship is at sea or in harbour, the difference in the expenses is very trifling. The principal cause of difference is the expenditure on coal while steaming. The ship has to be ready, with equipments, with the technical people on board, the electrician, the officers, and crew ; it has to be kept up as a man-of-war—in fact, ready for immediate service. A cable breaks, and in a few hours the vessel must start to effect the repair. Therefore, although the expenses appear large when a vessel is in harbour, there is no possibility of reducing them. You must have the ship in constant readiness to make repairs, and it would be quite impossible in the West Indies—in London even—to get a crew together in the short time in which it is necessary to be at work on a broken cable. I may say that I am a great stickler for economy. I should not wonder if I heard that some of my friends connected with this business had termed me a "tremendous screw," and when I am spending your money I feel that I ought to be "a screw." However, as to that matter, if I were ever to attempt to relax the purse strings, I think my colleagues on both sides of me, and also the excellent permanent officers of the Company in London would pull me up. Upon any question of expenditure I think we could justify ourselves to the utmost. The traffic returns, although they have been good for us in this half year—the first half year—I am sorry to say, show a decrease in the current half year, as you may have observed, from our published returns of about 10½ per cent. This is disappointing, but still, having in view the great commercial depression that pervades the world, and which is particularly severely felt in the West Indies, I do not know that it is very much to be wondered at. I think the wonder is, perhaps, that we have not felt it sooner. I hope a better time is coming for all countries in the matter of trade, and certainly any revival would benefit us in the West Indies in the sugar business. When I last addressed you I mentioned that there had been a rise in the price of sugar, but since then there has been very little advance, and sugar is at very much the same figure as when I last addressed you. But, after all, the fluctuations of our traffic receipts have not so much to do with our prosperity as the amount of repairs. If we have a light season in repairs we shall have very much better returns to put before you. The cables are, I think, giving less trouble than any used to. We have put in a large amount of new cable in our repairs from time to time, and I think that comparative freedom from interruption is showing itself. I announced to you last year the repairs of the original Jamaica-Porto Rico cable. That has given us no trouble since. That cable had been inoperative for 10 years. It is an important section of 700 miles. We put in 232 miles of new cable, and it has worked most satisfactorily ever since—in fact, during the interruption to the other cable it maintained communication with the whole of the West Indies, which would otherwise have been cut off. We have another difficult job before us. The cable between Santiago and Jamaica has been inoperative very much in the same way as the Jamaica-Porto Rico cable. In the year 1878 we laid a duplicate cable there, which has worked perfectly ever since ; and we have now to turn our attention to the old Santiago-Jamaica cable. It lies in very deep water. Some of the soundings show a depth of 3,000 fathoms. We have tried to lift it, but hitherto we have not been able to get it up to the surface at that very great depth. Its position, too, is dangerously near the other cable. I think in places they are only about six miles apart, and if you consider the operation of lowering a grapnel three miles into the sea, and attempting to recover the cable at that distance from the surface, without any bearings to guide you, you may fancy what nervous work it is, lest we should get hold of the other cable. We have ordered the "Grappler" home to take out 250 miles of cable, and we shall have an opportunity of consulting the captain of that ship, with whose experience in recent work on that cable before us we shall, I think, be able to form some plan of operations. I hope before we meet you again we shall be able to say that that cable has been put in order ; but it is impossible to say what amount of new cable may be required. No doubt we must abandon some of the old cable, but whether all will have to be replaced by new cable I cannot say. It is a matter of 150 miles, and it may take a very considerable amount of cable to repair it. I do not know that anything more occurs to me to remark

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upon. As long as the West Indian trade is in its present low condition we cannot expect any increase of revenue; and we cannot certainly expect any increase of subsidies in the depressed state of the West India colonies. If we could only get our cables to be more durable, and save expenditure on them, we should have a more prosperous condition of affairs to report to you. I now beg to move the following resolution :—

"Resolved, that the Directors' report and accounts to 30th June, 1885, submitted to this meeting be, and the same are hereby received and adopted, and that as recommended by the Board a payment of 9s. per share on account of arrears of dividend on the first preference shares be and the same is hereby declared."

Mr. WILLIAM FORD briefly expressed his pleasure in seconding the motion.

Mr. GUESDON said he desired to congratulate the shareholders on the very satisfactory position in which the Company stood, and to recognise the firmness which the Directors had shown in building up a reserve fund. It was a matter of the highest importance to all companies that a good reserve fund should be held, and perhaps this was of more importance to this Company than to most others. He would also congratulate the Directors on the nature of the investments which had been made on account of the reserve fund—investments which would not place them in any difficulty if they wanted money. The reserve fund was large, no doubt, and he hoped it would go on increasing till the Board felt that the Company was strong enough to pay the balance due on the preference shares. No doubt they were all anxious for a good dividend, but the question of primary importance was the stability of the Company. As to the depreciation of the ships, they had a very respectable sum for that. He supposed that the two ships were put down at what they originally stood at in the books. He also noticed an amount of £1,820 for insurance. He would like to have some information as to the cost of the insurance, because in a certain company a few years ago he introduced a scheme of insuring the ship among the shareholders. That was done in a way not to cause the slightest risk. The shares were deposited at a very small price compared with their market value, and they were deposited without reference to the position of any shareholder as the amount underwritten. He merely suggested that for the consideration of the Directors. It was better to keep among themselves any money they could keep. He supposed the £1,820 would indicate a sum not insuring the full value of the vessels.

The CHAIRMAN : They are insured for their full value.

Mr. GUESDON thought in case of average they stood in a very bad position.

The CHAIRMAN : We found the advantage of it in the case of the "Investigator." It is not the market value of the vessels that we insure on, but at what we could replace them.

Mr. GUESDON (continuing) said he would merely throw out the suggestion he had made for the consideration of the Directors—whether with such a large depreciation it was good policy to insure their ships up to their full value. There was an amount of £74 in the statement of general expenditure in London. The secretary had sent him a communication containing the information he had asked for as to how that item was composed, and he presumed it included nothing more than was stated. He, however, had found that lunches formed a considerable item in the expenses of joint stock companies.

The CHAIRMAN : Is there not a postcript there ? Mr. Guesdon called at the office, and afterwards sent a letter asking for the particular items forming that £74. I suspected he had lunches in his eye [laughter].

Mr. GUESDON : I had.

The CHAIRMAN : When the secretary put his letter before me I said : Give Mr. Guesdon all the details, and put in a postcript "no lunches" [laughter].

Mr. GUESDON said he had not noticed the postcript, not having read the letter with sufficient care. As to the great question of the cost of management, taking the average, which he presumed would be the case in most joint stock companies, the Directors held a meeting once a fortnight.

Mr. FORD : Once a week.

Mr. GUESDON : Then you are a very active Board.

Mr. FORD : And we find plenty of work to do.

Mr. GUESDON : Then, in that case, it would only cost £40 for each Board meeting ; but that was very large in a company like theirs. He said that without any idea of disparaging the services of the Board, for he believed that the Company was thoroughly well managed. Still, the amount represented a very large expenditure for them to incur. He had been pleased to hear the Chairman state that he was a great "screw," and he would be very glad if the Chairman would apply the screw at home. He noticed that the present market value of the whole of the stock held by the seven Directors represented £3,700, and while he did not wish to be invidious, and would be very unwilling to point to the holding possessed by any one member, he wished to say that there were two members of the Board who held about two-thirds of the amount he had stated. Consequently the other five members would receive annually for their fees rather more than the whole stake they held in the Company. The question in his mind was whether the Directors were not in excess of the number required by the necessities of the Company, and whether, both in number and amount paid, there could not be a reduction. He would move no resolution on the subject, but if the number of the Directors were reduced, and the remuneration brought to something like £1,000 or £1,200 a year, it would be a very acceptable increase to the revenue of the Company.

Mr. HORA reminded the shareholders that the Directors took office under certain conditions, and certain fees were promised. The matter had been thrashed out at previous meetings. The Directors had intimated that they were quite willing to place their seats at the option of the shareholders at any moment.

The CHAIRMAN, in reply, said, with regard to the question of insurance we pay between six and seven guineas per cent.

Mr. GUESDON was understood to say that he would give any security for a portion.

The CHAIRMAN : We will consider the question you have placed before us. Sir James Anderson reminds me that there is one thing shareholders might not like in insuring, which is protection against collisions. If the ship we collided with and sank was a valuable ship, it would be a serious matter, and we are protected from that now.

Sir JAMES ANDERSON : It is not your own ship only that you insure against.

Mr. GUESDON : You are only liable for so much per ton, not the value of the ship.

The CHAIRMAN : Well, we will consider what you have said. The question of the Directors, as Mr. Hora has said, has been thrashed out at almost every meeting we have had, and Mr. Guesdon in 1881 made a very vigorous attack on us in the same direction ; but after an explanation had been given (I have before me what you said on that occasion), you asked for everything that you had said to be expunged, as you had spoken in ignorance of the conditions on which the Company had been remodelled.

Mr. GUESDON observed that one was privileged to review one's decision of four years ago. The simple question, however, was whether the appointment as a Director was one for life.

The CHAIRMAN : Practically you discussed the question yourself then, and were of opinion that your remarks were not quite tenable. (Having quoted from the shorthand notes in support of this view), he continued : We were called into office at a critical moment. The Company had never up to then earned a farthing, and was practically in a bankrupt state. The present Board had had nothing to do with the Company then, and they were called in to do the best they could for a very tottering concern, and certain terms were held out for their remuneration. I have always said that I am perfectly willing to place my seat at your disposal, but as long as we remain here we shall expect to draw our fees.

Mr. VEARS said he regarded the complacency of the second preference shareholders as extraordinary ; and he was only an ordinary shareholder in the Company, a position which was something shocking. The facts laid down in the report were undeniable ; but surely there was some equity in the case. He said that the Directors were holding to the policy of these large additions to the reserve fund.

Mr. FORD : No, no.

Mr. VEARS : How am I to understand Mr. Ford's attitude ?

Mr. FORD : By seeing the diminished amount placed to the fund. You will find that in the last three half years we have reduced that amount.

Mr. VEARS : Still, you have added to it in the aggregate.

Mr. FORD : Certainly, because we think the amount has not reached an amount sufficient for our purpose.

Mr. VEARS, continuing, said he had no doubt that the Directors believed in their policy as to the reserve fund, but he maintained that, if he could speak of the equity of the position, he might ask for something for the ordinary shareholders. The character of the investments had been lauded by Mr. Guesdon, but he saw that they were getting 4 or 4½ per cent. from them, while they were paying 6 per cent. for their debentures. If the reserve fund could be made less and the ordinary shareholders could receive some return, the Directors would have the pleasure of knowing the benefit they had conferred on those unfortunate individuals, and he felt that they would also be freer in their consciences [laughter].

The CHAIRMAN : I am afraid our consciences would drive us to pay the unpaid dividends on the preference shares before we paid anything to the ordinary shareholders. As to the debenture debt, that is not due till the end of the coming year. When that time comes, no doubt, we shall be able to make some other arrangements. I do not suppose we shall be obliged to pay 6 per cent. again. At the time we raised that debt we had practically no reserve fund.

Mr. FORD : There was no back to the Company.

The CHAIRMAN : We have very much improved in our position since then. In answer to a remark of Mr. Griffith, the Chairman said : I stated that I would consider Mr. Guesdon's proposal as to insuring the ships. It is a new proposal to me.

Mr. GRIFFITH said it was also new to him. If they could obtain the benefit suggested by Mr. Guesdon it would be an advantage. On the other hand, they must remember that the insurance of ships was very hazardous, and that unless persons were fully competent to meet the risk they undertook, it would not be wise for the Board to insure in the manner suggested. He thought the Directors ought most carefully to consider any step they might take in the matter. As to what had been said about equity, contracts were contracts, and according to English law there was no equitable interpretation of a contract—the terms of the contract were upheld. If, however, the Company continued to advance as it had in the last six months, no doubt the second preference shareholders, and afterwards the ordinary shareholders, would receive something. The reserve fund was growing, and the Board, perhaps, might not think it would be necessary to add much more to it beyond the interest derived from the investments.

The CHAIRMAN : With respect to the remarks which have been made about the reserve fund, you know that this is properly speaking a depreciation fund. It is depreciation which goes on from year to year, and which we have to meet. No doubt we were very much behind with our reserve fund, and we had to build it up more rapidly than it may be necessary to do in future years. I do not think I am going too far in saying that there may be some relief to the shareholders as to this question of the reserve fund ; but the reserve fund is calculated on the basis of so many years' life of the cables and the interest we are getting on secure investments. It is constantly rolling up, but until it reaches what would replace the cables I cannot hold out any hopes that additions to the reserve fund will absolutely cease, though I think they will be reduced.

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It all, however, depends on circumstances. We may have to draw upon that reserve fund. This cable repair that we have now to work at may cause us to dip into it.

Mr. GRIFFITH: But there is a depreciation fund.

The CHAIRMAN: What could you replace the cables for?

Mr. GRIFFITH: You can lay a cable to America for £400,000.

Mr. HENRY WEAVER: Would you introduce me to a contractor who would do that?

Mr. GRIFFITH: That was the price paid by the Anglo-American Company.

Mr. WEAVER: No; I beg your pardon.

Mr. GRIFFITH stated that in the Cuba Company they paid an annual sum to the contractor, which was part of the original purchase money, and he in return for that undertook to repair the cable.

The CHAIRMAN: They have a reserve fund as well. That is only as to one cable, as to which, no doubt, they made an excellent arrangement. It was cable lying on the hands of the Company from whom they purchased it.

Mr. FORD: It was an exceptional arrangement. The people had the cable on hand and wanted to get rid of it.

A SHAREHOLDER asked when the ordinary shareholders were likely to receive a dividend.

The CHAIRMAN: You can judge from the accounts. Our first duty is to the preference shareholders. We must first wipe off the accumulation of arrears on the preferences, and we are taking one step towards it now. If our repairs cost us very much less and our position improves we shall make more progress in paying off that liability; but before that is done I see no hope for the ordinary shareholders.

Mr. BARHAM said that though he was rather a large shareholder in the concern, he did not think they ought to starve the reserve fund. He hoped the Directors would have the moral courage to keep that going on, as the future of the Company depended upon it.

A SHAREHOLDER said he hoped when the present debentures fell due the new ones would be offered to the shareholders first.

The CHAIRMAN: The debentures are not due till the end of next year, and we cannot really say what we shall do so long beforehand.

Mr. ROBINSON KENDAL said he hoped that before that time came the Company would be in a position to pay off the debentures and not be obliged to renew them. Mr. Vears had asked whether the Directors could do anything for the ordinary shareholders. If he (Mr. Kendal) thought they could he would move a resolution on the subject. As to the question of insurance, he trusted that the Board would not for a moment listen to the nonsense that had been talked at that meeting in regard to that question. Insurance at all times as to steam vessels was a delicate and hazardous matter, and it was eminently so in regard to cable steamers. He trusted that the ships would be insured in very good offices, and up to the full amount, so that the Company could lose nothing; and he hoped the Directors would not (he was sure they would not, as business men) entertain any question of dealing in the way suggested with the insurance of the Company's ships.

The CHAIRMAN then put the resolution, which he declared carried unanimously, adding that that closed the business of the meeting.

On the motion of Mr. GUESDON, seconded by Mr. BARHAM, a vote of thanks was passed to the Chairman.

The CHAIRMAN having acknowledged the vote, the proceedings terminated.

The Pilsen, Joel, and General Electric Storage Company.

The fourth ordinary general meeting of the shareholders of this Company was held on Thursday last at the City Terminus Hotel, Cannon-street, Sir Rawson W. Rawson, K.C.M.G., C.B., presiding.

The SECRETARY (Mr. W. H. Trentham) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN then said that the report, which was a very short one, laid before the shareholders frankly and fully the position of the Company at the present time. The Directors had succeeded in carrying out the policy which was approved at the last two meetings. They had got rid of the obligations connected with their factory and office; they had reduced the expense of management to a minimum; they had put the Company in a way of working at a profit; and they had held in view the most important point to the shareholders, namely, to avoid being under the necessity of making any further call. They had now invested on behalf the Company £3,000, besides the balance in hand and at the bankers. They were working at a profit, and they had every reason to hope that the difficulties with regard to the arc light would be overcome. They must remember that their patent was that for the arc lamp, which was not available for lighting houses or small areas, but was specially applicable for large areas, streets, factories, and suchlike places. The time was now at hand when the public and the legislature would equally recognise the necessity of removing the restrictions which had hitherto prevented the development of the electric light, and the Company had every indication at the present moment, by the tenders which they had been called to make, by the enquiries that had been made at the office, by the general acceptation of the Pilsen arc lamp as being practically the best before the public, and by the fact that their patent was one which could not be superseded—it might be improved upon by themselves, but it could not be superseded by others—that there was a good future for the Company. The Directors had succeeded in avoiding what many wished—the winding up of the Company and the distributing of the assets, such as they were. They had moreover placed the concern on a footing which he trusted would enable them, on the present economical scale of working the business, to give the shareholders something in return for the capital which they had invested. Having invited discussion, he concluded by formally moving the adoption of the report and accounts.

Mr. ELLIS seconded the motion.

The CHAIRMAN, in reply to Mr. Fyfe, said that the valuation of the Company's property was made by the manager last year, and it was founded upon the usual principle of allowing a reasonable amount of depreciation. This year after their experience of the auction, and with the advice and assistance of their auctioneer, who was exceedingly skilled in the valuation of machinery and such stock as the company possessed—the property was revalued, and was put down at what the auctioneer expected it would sell in the market if they were obliged to sell.

Mr. HORACE W. SCRIVEN, in further reply to Mr. Fyfe, assured that gentleman that the Board had not tried to make the stock of less value than it would fetch in the market, but they had studiously avoided putting upon it any fanciful price.

The CHAIRMAN, at the request of Mr. King, pointed out that a printers' error in the published accounts made it appear that the capital as reduced was 28,000 shares of £4 each, of which £2. 5s. had been paid, whereas it should have been £3 each. £1 had been written off as lost, and £1 had been written off as reduced, so that the liability was really 15s. per share.

Mr. FYFE complained of the price at which the Joel lamps were sold.

Mr. JOEL explained that the Secretary wrote to him and said that an offer had been made to the Company of £20 for the lamps, and asked whether he (Mr. Joel) would not give them more than that figure. He accordingly gave £5 more for them in order to prevent their being forced on the market, and he had them now.

The CHAIRMAN said the Directors had done their best. They had had a very toilsome year in trying to advance the interests of the shareholders. If gentlemen thought that better things ought to have been accomplished, he wished that they had only been in the Directors' places.

A discussion then ensued as to the propriety of cancelling all those shares on which arrears had not been paid. The general feeling of the meeting, however, was in favour of leaving the question to the discretion of the Board.

The retiring Director, Sir Rawson W. Rawson, was subsequently re-elected to his seat at the Board, and the auditors, Messrs. Broom, Hays, and Akers, were reappointed.

By another resolution, after a short discussion, the remuneration of the Directors was fixed at £100 each, and a vote of thanks having been accorded to the Chairman for presiding, the proceedings terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. Nov. 18.		BUSINESS DONE WEEK ENDING NOV. 18. Highest.	Lowest.
Anglo-American	84½,	85½	85½	82¾
Do. Preferred	57½,	58½	58½	54½
Do. Deferred	11½,	12½	12	9½
Brazilian Submarine	10¾,	11	11½	10 3-16x d.
Cuba	12½,	13	12 15-16	12¾
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9⅝,	9⅞	10	9 11-16
Eastern Telegraph	11⅝,	11⅞	11 13-16	11⅝
Do. 6 per Cent. Preference	13½,	14	—	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅞,	13⅛	13⅛	12 13-16
German Union	9½,	10	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7⅛	7
Do. Preference	13⅛,	13⅜	13⅜	13⅛
Great Northern	13⅞,	14⅛	14	13⅞
Indo-European	82,	83	81¾	—
Reuter's	7¼,	7¾	—	—
Submarine	205,	215	—	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	9,	9½	9¾	9¼
Western Brazilian	5⅝,	5⅞	5⅞	—
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅞,	1	1	15-16 x.d.
Oriental	3-16,	5-16	—	—
United Telephone	12¼,	12¾	12¾	12¼ x.d.

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3½,	3¾	3 11-16	2½
Do. (fully paid)	5,	5½	5 9-16	4 7-16
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1,	1¼	1 3-16	— 15-16
Maxim-Weston	¼,	⅜	5-16	—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37¼	36½
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24½	24

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NOTES.

THE ELECTRIC LIGHT AND MADRAS.—The Madras Club has been lighted with electric light as an experiment.

APPOINTMENT.—Señor Don Saturnino Islas has been appointed Director-General of Telegraphs to the Mexican Government.

POSTAL APPOINTMENT. — Mr. A. S. Roberts, assistant superintendent, Central Telegraph Office, has received the appointment of Postmaster at Normanton.

THE VIENNA ELECTRIC RAILWAY.—The electric city railway project of Messrs. Siemens and Halske at Vienna, Austria, has received the sanction of the authorities.

THE BLACKPOOL ELECTRIC TRAMWAY.—The electric tramway on the promenade in Blackpool is now in full working order, and cars driven by electricity run daily.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended 13th and 20th inst. amounted to £3,063 and £2,633 respectively.

WHEATLEY v. THE CONSOLIDATED ELECTRIC COMPANY.—Owing to the sudden death of Mr. J. Beaumont, who was engaged in this case, the further hearing has been adjourned.

THE ATLANTIC COAST.—Advices from Philadelphia state that the high tides continue on the Atlantic coast, from Chesapeake Bay to New England, interfering with the shipping, railroads, and telegraphs.

THE TELEPHONE IN FRANCE.—The Havre Chamber of Commerce has addressed a note to the Minister of Posts and Telegraphs relative to the inefficiency of the telephone service between Rouen and Havre.

THE WAR WITH BURMAH.—A telegram from Calcutta reports that it is officially announced that Press telegrams from the seat of war in Burmah have been stopped. The reason for the step is not known.

THE SERVO-BULGARIAN WAR.—A telegram from Sofia, dated Nov. 22, says:—"On the strength of the St. Petersburg Convention of 1875 the Diplomatic Agents here have been informed that they may not telegraph in cipher."

LUMLEIAN LECTURES, 1886.—Dr. Stone has been nominated by the Royal College of Physicians to deliver this course in April next. He has chosen as his subject "The Electrical Conditions of the Human Body—Man as a Conductor, Condenser, and Electrolyte."

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the weeks ended 13th and 20th November were £2,359 and £1,885, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

RUSSIA AND CENTRAL ASIA.—As briefly announced in our last issue, the telegraphic line is now open to Penj-deh, the section from Merv to that place, a distance of two hundred and ten versts, having been hastily constructed in view of the greater facilities it would afford to the Commission of Delimitation.

THE INDUSTRY AT MONTREAL, CANADA.—The equipment of the American Electric Manufacturing Company's new factory at Montreal is about completed, and will soon be put in operation, with advance orders on hand for dynamo machines and lamps sufficient to keep it running from four to six months.

MORE ATLANTIC CABLES.—We strongly advise that not a single farthing be invested in any new Atlantic cable company, as it is impossible that any return can be realised from such investment, and we emphatically protest against any attempt being made to obtain money from the public for this purpose.

A MISSING BALLOON.—Advices from Paris state that a balloon, named La Vénus, containing MM. Falubas and Thomas, and illuminated by the electric light, started recently from Montmartre on its aerial voyage. Nothing has been heard of it since, and it is feared that an accident must have occurred.

THE ELECTRIC LIGHT FOR TRAWLERS.—The series of experiments lately carried out upon the North Sea trawling vessels, with a view to lighting them by electricity, has, on the whole, proved satisfactory. The lighting of fishing boats by electricity would be invaluable, were it not for the heavy cost involved in this project.

A DIRECT CURRENT TELEPHONE.—A contemporary gives a glowing account of a telephone invented by Mr. Guthrie, of Leesburgh, U.S.A. As far as we can make out the instrument is operated on the closed-circuit principle, as in telegraphy, contact being made and broken by the vibrations of the diaphragm when spoken against.

AN AMERICAN TELEPHONE STORY.—This conversation is said to have actually occurred at the Central Hotel, Cherry Valley:—Man: "Is there a telephone here?" Operator: "Yes, sir." Man: "Can I send a message to Little Falls?" Operator: "Certainly. To whom do you wish to send?" Man: "I've forgotten the man's name; that's what I want to telephone for."

THE KALAHARI DESERT.—It is said that a hot electric current sweeps over the Kalahari desert from north to south, at the end of winter. In connection with this wind it has been asserted that the Bechuanas knew of the electric spark ages before it was produced by Dr. Franklin. The wind seldom blows from north to south; that from the north is hot, and from the south cold.

BOOKS RECEIVED.—"The Turkish Bath in Diseases of the Heart, Obesity, and Atrophy," by Richard Metcalfe. London: John Heywood.—"Examples of Exercises given in the Natural Philosophy Class of Glasgow University, with Indications how to Answer Them," by M. Maclean, official assistant to the Professor of Natural Philosophy in the University of Glasgow. Glasgow: James Maclehose and Sons.

PERSONAL.—Mr. G. W. Morrison, Town Clerk of Leeds, has received from the Prime Minister a letter stating that the Queen intends conferring upon him the honour of knighthood, especially in commemoration of the fact that he was the originator of the Municipal Corporations Jubilee, recently celebrated. Mr. Morrison gave evidence before Mr. Chamberlain's Committee on Electric Lighting, the said evidence consisting of a recapitulation of the views of an electrician who was even more of an amateur than Mr. Morrison.

IS CAPACITY VARIABLE?—In the current issue of our contemporary, the *Electrical Engineer*, there appears an article in which the above question is asked. The writer is of opinion that long exposure to the heat and humidity of a tropical climate has a deteriorating effect upon both condensers and submarine cables, and also points out that the observed capacity of a cable in comparative deflection tests must vary with its insulation resistance, in that there is a variable loss of current in the interregnum between charge and observation.

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In Liquidation.—Notice is given that a general meeting of the shareholders of the Mediterranean Extension Telegraph Company (Limited) will be held at the Cannon-street Hotel, on Monday, the 21st prox., at one o'clock, for the purpose of having the accounts of the liquidators laid before them, showing the manner in which the winding up of the affairs of the company has been conducted, and the property of the company disposed of, and hearing any explanation that may be given by the liquidators. Messrs. Ashley Ponsonby and John G. Griffiths are the liquidators.

Cambridge University.—The adjudicators of the Smith Prize announce that the essay by Mr. Charles Chree, B.A., Fellow of King's College, on "Elastic Solids," and the essay by Mr. Alfred North Whitehead, B.A., Fellow of Trinity College, on "The General Equations of Hydrodynamics," are deserving of honourable mention. The subjects of the essays, which were declared of equal merit for the prizes, were "The Distribution of Electricity on the Circular Disc and Spherical Bowl," written by Mr. E. G. Gallop, and on "Systems of Circles," written by Mr. R. Lachlan.

Telegraphic Communication with our Colonies.—We have good reason to believe that the present Government has, during its already short tenure of office, considered very carefully the advisability and possibilities of connecting by cables completely under English control most of our outlying dependencies not yet so connected. Several plans have been suggested so as to obtain as far as possible alternative routes, and not to be compelled to depend solely upon single cables. We have for a long time strongly advocated the adoption of some system, and trust that the work will be vigorously pushed forward.

Telegraph Stores.—The Directors of the North Eastern Railway are prepared to receive tenders for telegraph apparatus and telegraph wire and line stores, in such quantities as they may require, during the six months ending 30th June, 1866, delivered carriage-paid at the company's telegraph stores at York. Payment for each month's delivery will be made at the end of three clear months, or in cash less 2½ per cent. discount. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York, and tenders must be sent in to the secretary at York, sealed and marked "Tender for Telegraph Stores," not later than noon on Tuesday, the 1st December.

Gas in Glasgow.—According to recent statistics of the street lighting in Glasgow, it appears that for the year ending May 31st, 1885, there were in the public and private streets, courts, &c, 12,766 lamps, consuming 96,484,973 cubic feet of gas, which, at 3s. 6d. per 1,000 feet, yielded to the Gas Trust £16,884. 17s. 5d. The estimated consumption in the public and private street lamps for the year ending May 31st, 1886, is set down at 103,323,543 cubic feet, and that of the stair lights at 72,124,808 cubic feet; being a total of 175,448,351 cubic feet. This quantity, at 3s. 3d. per 1,000 cubic feet, represents a payment by the Lighting Department to the Gas Trust of £28,510. 7s. 2d.

A Visitation of Earthquakes.—M. Delaunay, of Paris, predicts that earthquakes on a grand scale will occur next year either when the earth is under the influence of a planet of the first rank, such as Jupiter, or under that of a group of asteroids, or at a time when the sun and moon are nearest to our planet simultaneously. This specialist in earthquakes foretold the frightful catastrophes which occurred in South America in 1877. He announced a vast seismic disturbance in 1878, and the appalling disasters in the Indian Archipelago followed. He raised his voice of warning also before the late extensive shaking of the earth in Spain. It is no wonder that his latest utterances have caused considerable attention in various countries.—*Kuhlow.*

Continental Notes.—The installation put down in the shops of the Maison Boudet at Paris has been modified. Formerly the current was supplied from batteries of the Société le Chrome. Now, however, these have been displaced, and a dynamo, driven by a gas engine, substituted for them.—The Exposition du Travail closed last week.—It is said that the Cirque now in process of construction in the Rue Saint Honoré, Paris, will be lighted by electricity. The installation will consist of no fewer than 800 Edison 8 and 10 candle-power incandescent lamps, supplied from two Edison dynamos, and a battery of Barrier and Tourvielle accumulators, furnished by M. Duplay. There will also be a number of sun lamps supplied by alternating current machines on the Maquaire system.

The Electric Light and the St. James's Vestry.—At a recent meeting of this Vestry Board the Lighting Committee recommended, with reference to the letter from the West London Electric Lighting Company as to the delay in commencing operations under their order, that the company be informed that the vestry regret that the company should now appear to raise any objection to proceeding with carrying into effect the Electric Lighting Order obtained by them in 1884, until clause 27 of the Electric Lighting Act of 1882 has been altered, inasmuch as the company were fully acquainted with the provisions of the law before the order was granted to them, and that the vestry hope the company will take steps for carrying the order into effect without any undue delay. The report was accepted.

Isolated Plants in America.—According to recent statistics there are in America a total of 451 plants and 97,424 lamps, of which 368 plants and 78,432 lamps were of the Edison system. The company has, however, increased its output to 520 plants and 132,875 lamps up to October 1, or an increase, taking this basis, of 41 per cent. on plants and 69 per cent. on lamps. It is also worthy of note here that there are in use 88,000 lamps, additional, in central stations devoted wholly to the work of supplying the public in the same manner as do gas works. Another interesting feature of the work of the company in 1884-5 was the number of installations in exhibitions. The list is as follows:—Louisville, 5,000 lamps; St. Louis (permanent), 3,600; New Orleans, 5,000; Cincinnati, 1,200; Boston, 1,200; Milwaukee, 800; Philadelphia, 3,000.

The Commercial Cable Company.—It is rumoured in the City that an endeavour will shortly be made by the Commercial Cable Company to issue £600,000 six per cent. debentures. It will be remembered that this company has laid two cables in opposition to the existing Atlantic cable companies, at a time when there is no prospect of anything like sufficient work for the older cables. We are now told that another scheme is being promoted to lay an Atlantic cable *vià* the Azores. Surely speculative credulity will hardly go so far as this; but if foolhardy speculators should be found to make the attempt, we strongly advise the existing companies to fight, and to fight in such a manner that the opposition must end in perfect failure. Legitimate competition is all very well, but this is not legitimate competition, for it is absolutely impossible to put forward any good reasons for promoting such a scheme.

The Persian Gulf Cable.—It is announced that the new telegraph cable between Bushire and Jashk, in the Persian Gulf, has been successfully laid. On the 8th of October we stated that the steamship "Dacia," with Colonel Bateman-

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Champain, R.E., the Director-General of the Indo-European Telegraphs, and Sir Henry Mance, C.I.E., the electrician, had started from the Thames with the first portion of the cable. The steamship "International," which left England with the other half of the cable a few days after her consort, met her at Jashk on the 12th instant, when the operation of paying out was commenced, and the whole cable, 530 miles in length, was laid in perfect condition on the 20th instant. Mr. D. W. Barker has received the following telegram from his son, Captain Barker, of the telegraph ss. "Dacia," now in the Persian Gulf:—"Shirez, 21st Nov., 9:10 a.m., and received in Worcester at 10:4 : Cable successful, all well."

QUERY TELPHERAGE?—An American contemporary says that there is on exhibition at No. 1, Pemberton-square, Boston, an ingenious model exemplifying a new system of rapid transit. The work is the result of years of labour by Mr. John A. Enos, a young electrician, and consists of a passenger car suspended from a rail upon which runs an electric motor. The latter is of the Daft pattern, and receives its power from an electrified rail, furnished from powerful steam dynamos. The cars may be either suspended in the air or move near the ground. The cars are lit by electricity and worked entirely from the inside. The elevated track, being a single rail, does not darken the street. A stock company is being formed to introduce the system in Boston. The patentees have about completed arrangements to put it in operation between Lynn and Nahant. The Legislature will be applied to for the granting of a charter and the right of way through the city.

AUSTRALIAN NOTES.—Advices from New South Wales report that the new system of paying for telegrams by postage stamps is now in operation in the colony. The working of the system in Melbourne was inquired into by Mr. P. B. Walker, Acting Superintendent of Telegraphs, and both Mr. Norton and Mr. Walker feel convinced that the new arrangements will prove to be very advantageous to the public.—South Australia now possesses about 5,500 miles of telegraph, and the length of wire is nearly 9,000 miles. In 1883 the gross value of the international messages was £251,277. Sawn jarrah poles are pronounced the best timber for carrying wires. The Transcontinental line was opened in October, 1872. The cost of construction was £338,059, or, including re-poling, &c., £479,175. Its length (from Adelaide to Port Darwin) is 1,975 miles. A line to Western Australia cost nearly £70,000. Communication was established between Adelaide and Perth in December, 1877.

TELEPHONE CHESS MATCH.—On Tuesday evening, through the courtesy of the National Telephone Company, a match at chess was played between four members of the Workington Chess Club and a like number of Maryport players. Four tables were arranged at Workington, at which sat Messrs. J. Higgins, D. Harkness, J. Urle, and J. C. Thompson. The various moves were spoken by means of the telephone, and the play went steadily and easily forward. The National Company made every arrangement for the working of the match at their offices at Workington and Maryport, and the interesting experiment was watched by a considerable number of invited spectators. The match is due to the arrangements of Mr. J. Higgins. Mr. Kirkwood, the local agent of the company, was present, and the officials received the congratulations of all present for the excellence of the circuit, and the ease with which the messages were sent and received. There was but one disputed move in all the games.

PROVISIONAL ORDERS OF THE BLACKPOOL CORPORATION.—Among the purposes for which the Corporation of Blackpool intend, during the coming Session, to apply for powers are the following:—The placing, removing, and prohibiting the erection of telegraph, telephone, and overhead wires. To revise and extend the powers of the Corporation under the Blackpool Improvement Act, 1879, for the production and supply of electric light, heat, and motive power. To break up and also to stop up, alter, divert, and interfere with, either temporarily or permanently, and if permanently to appropriate the site of and extinguish all right of way over and to cross over, under, or upon all such streets, roads, highways, bridges, thoroughfares, railways, tramways, rivers, streams, brooks, watercourses, sewers, drains, gas and water pipes, and telegraph and other electric apparatus, as it may be necessary or convenient to break up, stop up, alter, divert, interfere with, or cross for any of the purposes of the Bill, and to extinguish all rights of way and other rights in, over, or upon any lands to be acquired under the powers of the Bill.

AMERICAN ITEMS.—The New York Subway Company has been incorporated at Albany, with a capital of 5,000,000 dols., for the purpose of establishing electric communication underground in the City of New York, by the means of subways, cables and conduits.—The Fourth Electric Light Company applied for a franchise at Galesburgh, Ill., on 2nd inst.—The electric light is spreading rapidly in the American coal regions. Pottsville was lighted by electricity on the 16th inst., thirty arc lights being used as a beginning.—Denver, Col., will be lighted by electricity; incandescent lights are to be placed on every lamp-post. An electric railway is nearly completed in the same city.—General Hazen has gone from Washington to Boston for the purpose of superintending the laying of the new signal service cable that is to connect Nantucket with the mainland.—There is a project to put down a new street railway in Nahant, Mass., and electricity is to be the motive power.—Gas does not answer the requirements of the Brooklyn Elevated Railroad, which has a great many exposed stations. The company is in favour of incandescent lighting, and will in all probability try that system first on the new Fulton Ferry Station. If it proves satisfactory there, it will be adopted over the entire road.

A PROPOSED NEW CABLE.—Particulars will be found in our advertisement columns of an important undertaking, no less than the laying of a submarine telegraph cable between Halifax (Nova Scotia), Bermuda, and Jamaica, for which Her Majesty's Government are inviting tenders. The contractor must undertake to make suitable arrangements for the prompt transfer to and from the cables of the Atlantic and West India and Panama Cable Companies of all messages transmitted or intended for transmission by the proposed cable, so that a continuous and satisfactory service may be maintained between the United Kingdom and Bermuda and the British possessions in the West Indies. The subsidy may be for a term of twenty years, and will be payable at the end of each complete period of twelve months, provided that the cable has been maintained in good working order, and has been efficiently worked, and a continuous service between the United Kingdom and Bermuda and the British possessions in the West Indies has been in fact maintained. The communication must be established and in efficient working order within twelve months of the acceptance of the tender. The last day for the reception of tenders is Tuesday, the 15th proximo. They must be enclosed in sealed covers, marked "Tender for Bermuda Cable," must be addressed to the Secretary, General Post Office, E.C., and be delivered by 12 o'clock (noon) on that day. Her Majesty's Government do not bind themselves to accept the lowest or any tender.

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THE LIGHTING OF THE CITY.—At a recent meeting of the Commissioners of Sewers Mr. Altman, in answer to Mr. Deputy Bedford, said the Streets Committee had had a large number of applications from different electric lighting companies, which were still under consideration. With regard to the offer that the Commission should take over the plant of a particular company, and carry the lighting out on their own account, the committee had seriously considered the matter, and were of opinion that if the Commission felt disposed to take up electric lighting on their own account it would be better to buy new plant. The Commission was handicapped to a large extent by the present Act, and if it were possible to amend it their work might be very much easier. He hoped to bring up a satisfactory report at the next court.—Mr. Deputy Bedford was informed that the people who lighted Holborn-viaduct were prepared again to light the whole of it with double light for £500 a year. This was one of the most magnificent entrances into the City of London.—Mr. Altman said the offer of that company was still under consideration.—Mr. Deputy Ashby understood the committee were to consider and report whether it had power, and if so, whether it was desirable for the Commission to undertake, at its own cost, the supply of electricity; and, secondly, to appoint an area and give an estimate of the expense.—Mr. Altman replied that the committee would meet two hours earlier for the purpose of considering that.

THE BALL UNIPOLAR INDUCTOR DYNAMO.—The novelty in the electric light system of Mr. C. E. Ball, of Philadelphia, and the feature that distinguishes it from all others is that it has two armatures, each of which rotates within the inductive influence of only one pole of a field-magnet, while other forms of dynamos have one armature rotating within the inductive influence of two poles. The promoters of the enterprise make the following claims as to the excellent qualities to be found in the Ball unipolar inductor dynamo :—"The current is very regular, and produces an unusually steady and uniform light. It will sustain at the same time two circuits of lamps, one of the arc class and another of the incandescent, or it will run either class independently. Its capacity and performance are very remarkable, which may be inferred from the fact that one dynamo for operating 20 arc lights weighs but 780lb., while 2,000lb. is a light weight for one of equal capacity of any other system. It does not generate undue and excessive heat in its armatures, and consequently they offer with it no cooling device or ventilating apparatus, such as blowers, air blasts, fans, &c. It possesses the prevention and requires no cure. It does not require to be run at an exact speed, and any power of ordinary uniformity will produce good light as regards its mechanical detail. The shaft is steel, the bearings are bronze, and the ironwork is forged. The commutators are composed of unusually pure copper, formed by a peculiar process, which gives it great density and secures a uniform wear. The wear of the commutators and the consumption of brush copper is remarkably slight.

THE TELEPHONE AND THE CORK CORPORATION.—At a recent meeting of the Cork Town Council, the Secretary of Committees reported that in accordance with an order of Council the system of telephonic inter-communication had now been established between the various corporate offices. The arrangement was manifestly calculated to facilitate the transaction of business within the corporate organisation, being the next best thing to a concentration of all the offices in one place. The value of this corporate inter-communication was likely to be greatly enhanced, as far as the public were concerned, by the fact that the whole of the system was placed at the service of persons who were subscribers to the Cork telephone system established at the General Post Office. One special advantage to subscribers to the telephonic system of the General Post Office consisted in being enabled to call up the fire brigade at any moment day or night through the subscribers' own telephone. During office hours this would have to be done by first calling the Post Office, the latter then calling the office in the South Mall, where they would be put through to the brigade station ; but at night, when the mayor's office was closed, the Post Office and fire brigade station were placed in permanent communication. Mr. Julian said the report was an important one and was very satisfactory. It would enable parties to see how they could communicate with the fire brigade at night, and he was of opinion that the communication that was established between the different offices by telephone would result in a saving far more than they would be obliged to pay for the telephone to the Post Office. He thought the mayor's residence should also be placed in communication with the system, so that they would be enabled to call upon him at any time his services might be required.

THOMSON'S SOUNDING APPARATUS.—As considerable misapprehension exists, says a contemporary, as to the precise limits of accuracy and the legitimate use of Sir W. Thomson's sounding machine by Her Majesty's ships, the Admiralty have issued a memorandum on the subject. The working of the machine is simple, but in the hands of men not thoroughly acquainted with it failure is very likely to occur when soundings are obtained in an emergency, especially on dark nights and in heavy weather, under which circumstances the apparatus is most of service. After referring to the advantages and defects of the machine, their lordships remark that the error in a tube will generally be greater at the greatest depths, as the scale is a diminishing one, and the graduation above the 50 fathom mark becomes rapidly very small. The presence of any matter in the tube affects the compression of the air as the space unoccupied by water becomes smaller. No confidence is to be placed in a single cast. A continuous line of soundings is ordered to be taken, but without dispensing with the ordinary casts of the deep sea lead. The utmost caution is to be observed in attempting to assume the ship's position from the coincidence of a line of soundings by the machine with the soundings on the chart. From the liability to small errors in reading, this may give very erroneous results where the water shoals gradually, unless the correctess of the tubes has been verified by one or more casts of the ordinary lead. None of Her Majesty's ships are, unless under special orders, justified in running for the land in thick weather, relying on this machine as an unerring guide. From ships supplied with the machine valuable information is looked for as to inequalities of the bottom on many shores not yet thickly sounded over, from the facilities offered, by the method of working it, to obtain frequent soundings. In all cases, however, of discovery of banks, or shoaler soundings than marked, the accuracy of the depth indicated should be checked by an up and down cast of the lead and line. There are frequent cases on record of reported discrepancies of soundings over large areas and of banks, given on the strength of Thomson's machine, which have been disproved when examied with lead and line.

TELEGRAPHIC COMMUNICATION WITH WEST AFRICA.—An important aid to the commercial development of the West Coast of Africa will be the telegraph cable which will before the end of next year extend along its shores, touching at the principal ports and reaching to the mouth of the Congo and to St. Paul de Loanda. There at present exists telegraphic

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communication between Europe and Dakar, Senegal, *viâ* Cadiz, on the one hand, and between Europe and the Cape Verd Islands on the other. The cable steamers "Silvertown" and "Buccaneer" are now at work, connecting up the Cape Verd Islands with the mainland and prolonging the Senegal cable down the coast, so that in three or four months it is expected that Sierra Leone will find itself in duplicate telegraphic communication with Europe. The ports to be connected in this system of cables are the English possessions of Bathurst, Gambia, Sierra Leone, Accra, Lagos, and Niger; the French possessions of Dakar, Senegal, Conakry within 80 miles of Sierra Leone, Grand Bassam, Porto Novo, and Gaboon; the Portuguese possessions of Bulama, Bissao, St. Thomé, Principe, St. Paul de Loanda, and probably Congo. The Spanish Government are in treaty to have Fernando Po in connection with this system, and the German Government are also thinking of opening stations in the Cameroons district. The importance of this West African telegraph line to the development of commerce in these regions is self-evident, and has been recognised by the several Governments that have subsidised these new lines. When the cables are open for service there will be fewer of those surprise annexations of which we have had so many recently. In 18 months' time there will be a further extension of telegraphic communication along the coast, the Portuguese Government having contracted for the connection of Nova Redendo, Benguela, and Mossamedes; while the Government of Cape Colony has been authorised to subsidise a West African telegraph line, the laying of which will place that colony in duplicate communication with Europe, so that the colony will be independent of complications in Egypt. The completion of this line to the Cape gives a circle of communication round Africa, and consequently gives every point touched an alternative route. There have been recent complaints of the neglect of our West African colonies by the home Government, which does not seem to be devoting so much attention to this region as our more active French and German neighbours. France is steadily enclosing our colonies of Bathurst and Sierra Leone, by her acquisitions in the interior, and her extension of territory in this direction does not seem to be fully realised in London.—*The Times.*

THE ELECTRIC LIGHT IN NEW ZEALAND.—In October last a number of gentlemen proceeded to Mosgiel, near Dunedin, at the invitation of the directors of the Mosgiel Woollen Company, for the purpose of witnessing the illumination of their premises by the electric light. We understand that the directors, not feeling satisfied that kerosene lamps were adapted for night work, decided upon giving the light a trial. Accordingly, alternative tenders were invited and received from a London firm, a Christchurch firm, and Messrs. Fletcher and Co., of Dunedin. Acting on the advice of Mr. R. Clay Jones, electrician to the Union Steamship Company, Mr. Morrison, business manager for the Mosgiel Woollen Company, entered into arrangements witn Messrs. R. E. Fletcher and Co., for a 300 lamp service, and the light, after a fair trial, proved thoroughly satisfactory. The installation comprises an F2 Victoria dynamo, made by the Anglo-American Brush Electric Light Corporation, the Australasian patents being owned and represented by the Australasian Electric Light, Power, and Storage Company of London and Sydney, and who are represented in New Zealand by Messrs. R. E. Fletcher and Co. The machine supplies 300 Swan lamps of 20 candle-power each, at a speed of 450 revolutions per minute. In the colonies, the Melbourne General Post Office has three (900 lights), and the Victorian Houses of Parliament four (1,200 lights) machines of the same type and size as the one supplied to the Mosgiel Company. Several of this and smaller sizes are in use in New South Wales, and the New Zealand Government have ordered three for coast defence. The Union Steamship Company's new steamer "Mararoa" has also a 300-light Victoria dynamo. The lamps used are the new Swan-Edison. There are at present 239 lamps arranged in four main groups or circuits, as follows: No. 1 circuit—carding and spinning room 112 lamps, engine room 6, boiler house 4; No. 2 circuit—warping room 15, milling room 8, steam brush room 1, finishing room 16; No. 3 circuit—wool-scouring room 4, teasing room 2, wool-drying room 2, dye house 8, drying rooms 12, mechanics' shop 4, wool bins, store, and passage, 4; No. 4 circuit—offices 3, hosier rooms 6, stocking house 19, scouring house 2, outside lights 3, manager's residence 8. The weaving room has not been fitted up with the light at present, because the rooms are not worked at night. A few lamps were temporarily fitted up, however, and four looms shown at work, to enable visitors to judge of the advantage of the electric light for weaving. The lamps are suspended from the ceilings by neat plaid-plaited "twin" wires, and in most of the rooms are arranged so that whichever way they are looked at the rows are always in line, thus giving a very pleasing and orderly appearance. The majority of the lamps are fitted with conical metal reflectors, by which the bulk of the light is thrown downward upon the work, and so used to the best advantage. Some idea of the size of this installation, which is the largest in this colony (Rosslyn Woollen Mills, who also use a Victoria dynamo, coming next), may be gained from the fact that nearly one and a half miles of main conductor and fully two miles of branch wires have been used for running the various circuits. Every portion of the circuit is thoroughly insulated, and with a view of providing perfect immunity from fire every lamp in the building is provided with a cut out. In the warping room the lamps, by a special fitting, are allowed to travel to and fro with the warping machines, and can also be used in any position or at any angle. Special notice must be made of the very handsome and massive main switch-board which Messrs. Fletcher and Co. have made and fitted in the engine room. Four heavy polished brass switches with their fusible plugs control the four main circuits, and are mounted upon a polished slate slab 3½ft. by 2½ft. in size, the slab, in turn, being set in a handsome moulding. The main cables leading to and from the switch-board are also enclosed in ornamental mouldings; and the whole apparatus forms a very ornate adjunct to the installation. It is noteworthy that the whole of this work has been manufactured in Dunedin, as indeed have all the necessary fittings and plant, save and except the dynamo, the lamps, and the wires. In addition to the lighting, Messrs. Fletcher and Co. had fitted up an electro-motor of about four indicated horse-power. This was actuated by the current from the lighting dynamo, and was used to drive the hydro-extractor in the milling room. The electrical transmission of power has an undoubtedly important future before it in the colony; and we understand that the major portion of Messrs. Fletcher and Co.'s business is already in this direction, rather than in lighting contract for the transmission of over thirty horse-power, a distance of four miles being now in course of execution, and arrangements are also being made by which the Dunedin tram cars will be propelled by electricity instead of being drawn by horses. After a thorough inspection of the buildings, machinery, and electric apparatus had been made, the company repaired to one of the rooms, where light refreshments had been provided.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 7.)

Normal Electromagnetic Systems. Energy Conjugate Properties.

The specification of the complete state of the electromagnetic field at a given moment requires a knowledge of seven quantities. We must, in the first place, know the electric capacity and conductivity, and the magnetic permeability, c, k, and μ. Next, we require to know the electric and the magnetic force, E and H. From these five data we know, by the linear relations, the conduction current $C = kE$, the elastic displacement $D = cE/4\pi$, and the magnetic induction $B = \mu H$. We also know the electric energy $\frac{1}{2}ED$, the magnetic energy $\frac{1}{2}HB/4\pi$ and the dissipativity EC; all per unit volume. But, in addition, we require to have given the impressed electric and magnetic forces, e and h. Then, by the two equations of induction,

$$\left.\begin{aligned} \text{curl}.(H - h) &= 4\pi\Gamma = 4\pi(C + \dot{D}) \\ \text{curl}\,(e - E) &= 4\pi G = \dot{B} \end{aligned}\right\}$$

we know the true electric current Γ, and therefore the displacement current $\dot{D}$; and also the magnetic current G. As for the electrification, it is known because D is known, of which it is the divergence. The seven data may be otherwise stated; for instance, instead of E and H, we may have D and B, or C and B. As regards the number of distinct numbers on which these seven quantities depend, if we take any three rectangular axes of reference, the four vectors E, H, e, and h require three numbers each, making twelve, and the three operators c, k, and μ require three numbers each (if there be no rotatory k), making eighteen. Thus altogether thirty numbers are concerned; or thirty-three, if there be rotatory conductivity. In case of isotropy, the number is fifteen, owing to c, k, and μ being then simply scalars.

We not only know the complete state of the system, but the rate at which it is changing; for $\dot{E}$ and $\dot{H}$ are known, and therefore, if the impressed forces be given at every moment, we can find the changes it goes through under their influence; or, if they be absent, in settling down to a state of equilibrium.

The equation of activity at any moment is

$$\Sigma e\Gamma + \Sigma hG = Q + \dot{U} + \dot{T};$$

the left member being the total activity of the impressed forces in all space, and the right its equivalent, the sum of the dissipativity Q (Joule heat per second) and the rates of increase of the electric and magnetic energies.

Now, suppose no relative motion of masses is permitted, thus making c, k, μ functions of position only, and excluding the impressed forces brought into play by such motions. If now e and h be constant with respect to the time, the system will settle down to a steady state, in which $\Sigma eC = Q$ simply. If, further, there be no e in conductors, or, more generally, only such distributions as may cause elastic displacement, but no steady conduction current, the final field is simply that due to h and to the e left, and to electrification and its surface equivalent, the charges of conductors.

But, by the linearity of equations, the inductive phenomena during the subsidence to the final state under the influence of steady e and h may be got by superimposition. We may therefore, in investigating subsidence, take $e = 0$, $h = 0$, and no electrification or charges on conductors; so that the subsidence is to a final state of no E or H anywhere.

We then have, at every moment after removal of impressed forces,

$$Q + \dot{U} + \dot{T} = 0; \quad \ldots \ldots \quad (100)$$

the rate of decrease of the sum of the electric and magnetic energies being equal to the dissipativity. Q, U, and T are all necessarily positive, being sums of squares, or else of positive scalar products. (For instance $EC = EkE$; if C is parallel to E, it is a square kE^2; if not parallel, their mutual angle must be always acute). This necessary positivity is of the greatest importance, as it excludes the possibility of indefinite increase of normal systems of force left to themselves, making them always subsides either without or with oscillations.

Let next there be two systems of electric and magnetic force distinguished by the suffixes $_1$ and $_2$, so that their equations of induction are

$$\text{curl}.H_1 = 4\pi\Gamma_1; \quad -\text{curl}.E_1 = 4\pi G_1; \quad \text{curl}.H_2 = 4\pi\Gamma_2; \quad -\text{curl}.E_2 = 4\pi G_2.$$

Using the third and second of these, we find by space integration,

$$\Sigma E_1\Gamma_2 = \Sigma E_1\text{curl}.H_2/4\pi = \Sigma H_2\text{curl}.E_1/4\pi = -\Sigma H_2G_1.$$

Similarly, by the first and fourth, we shall get $\Sigma E_2\Gamma_1 = -\Sigma H_1G_2$; so that we have

$$\Sigma(E_1\Gamma_2 + H_2G_1) = 0, \text{ and } \Sigma(E_2\Gamma_1 + H_1G_2) = 0;$$

or,

$$\left.\begin{aligned} \Sigma E_1C_2 + \Sigma E_1\dot{D}_2 + \Sigma H_2\dot{B}_1/4\pi = 0, \\ \Sigma E_2C_1 + \Sigma E_2\dot{D}_1 + \Sigma H_1\dot{B}_2/4\pi = 0. \end{aligned}\right\} \quad . \quad . \quad (101)$$

If we add these, we shall obtain

$$Q_{12} + \dot{U}_{12} + \dot{T}_{12} = 0, \quad . \quad . \quad . \quad . \quad (102)$$

the equation of mutual activity. U_{12} and T_{12} are the mutual electric and magnetic energies, and Q_{12} the mutual dissipativity, or the excess of the total dissipativity when the two fields coexist over the sum of the separate dissipativities.

Let next the arrangement of E and H be such that in subsiding they change in magnitude only, not in distribution. Let E_0 and H_0 be the distributions at time $t = 0$, and at time t,

$$E = E_0\epsilon^{nt}, \quad H = H_0\epsilon^{nt}, \quad . \quad . \quad . \quad . \quad (103)$$

The constant n is the reciprocal of a time, and is of course negative, if the subsidence be real. The larger n the more rapid the subsidence. E and H thus defined constitute a normal system of electric and magnetic force.

Now,

$$\left.\begin{aligned} Q = \Sigma EkE, \quad & U = \Sigma EcE/8\pi, \quad & T = \Sigma H\mu H/8\pi, \\ = Q_0\epsilon^{2nt}, \quad & = U_0\epsilon^{2nt}, \quad & = T_0\epsilon^{2nt}, \end{aligned}\right\}$$

by (103), if Q_0, U_0, T_0, be the initial values. From this, $\dot{T} = 2nT$, and $\dot{U} = 2nU$, which makes the equation of activity (100) become $Q + 2n(U + T) = 0$; or the ratio of the energy left at any moment to its rate of leaving is constant, $= -2n$.

If then the two systems to which equations (101) refer be both normal, with rates of subsidence n_1 and n_2, we shall have

$$\left.\begin{aligned} Q_1 + 2n_1(U_1 + T_1) = 0, \\ \text{and} \quad Q_2 + 2n_2(U_2 + T_2) = 0, \end{aligned}\right\} \quad . \quad . \quad . \quad (104)$$

when they exist separately; and, in addition, when they coexist, the equations (101), in which $\frac{d}{dt} = n_1$ or n_2, according to whether it operates on the first or second system. Now $E_1D_2 = E_2D_1$, $H_1B_2 = H_2B_1$, and lastly $E_1C_2 = E_2C_1$ if there be no rotatory conductivity coefficient; so that (101) becomes

$$\left.\begin{aligned} \tfrac{1}{2}Q_{12} + n_2U_{12} + n_1T_{12} = 0, \\ \tfrac{1}{2}Q_{12} + n_1U_{12} + n_2T_{12} = 0, \end{aligned}\right\} \quad . \quad . \quad . \quad (105)$$

where $Q_{12} = 2\Sigma E_1C_2$; $U_{12} = \Sigma E_1D_2$; $T_{12} = \Sigma H_1B_2/4\pi$.

Between the equations (105) we may eliminate in succession either the Q, or U, or T. Thus we get, if we leave out the common factor $(n_1 - n_2)$,

$$\left.\begin{aligned} 0 &= U_{12} - T_{12}, \\ 0 &= \tfrac{1}{2}Q_{12} + (n_1 + n_2)T_{12}, \\ 0 &= \tfrac{1}{2}Q_{12} + (n_1 + n_2)U_{12}, \end{aligned}\right\} \quad . \quad . \quad . \quad (106)$$

which are the universal conjugate properties of normal systems.

The first tells us that the mutual potential and kinetic energies of two normal systems are equal. This being true at every moment during the subsidence, it follows, by (102), that the mutual dissipativity is derived from them equally. This is the interpretation of the second and third of (106), the second saying that the mutual dissipativity equals twice the rate of decrease of the mutual kinetic energy, and the third that it equals twice the rate of decrease of the mutual potential energy.

Any one of (106) enables us to decompose a given initial state of electric and magnetic force into the sum of normal

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distributions, when the nature of the latter has been found, and hence determine the manner of subsidence. Thus, let E_0, H_0, be the initial state, and E_1, H_1; E_2, H_2; E_3, H_3, &c., the various normal distributions, with constants n_1, n_2, &c. Let

$$\left.\begin{aligned} E_0 &= A_1E_1 + A_2E_2 + A_3E_3 + \dots \\ H_0 &= A_1H_1 + A_2H_2 + A_3H_3 + \dots \end{aligned}\right\}$$

where the A's are coefficients fixing the absolute magnitudes of the normal solutions. If the A's can be found, then, at time t later, we shall have

$$E = A_1E_1\epsilon^{n_1t} + A_2E_2\epsilon^{n_2t} + \dots ;$$

E being what E_0 then becomes; and a similar equation for H.

The A's are found thus :—E_0 and H_0 being given, and the rth coefficient A_r being required, calculate the mutual potential and the mutual kinetic energy of the given state with respect to the rth normal distribution. Let them be U_{or} and T_{or}. Their values are

$$\begin{aligned} U_{or} &= A_1U_{1r} + A_2U_{2r} + A_3U_{3r} + \dots + A_rU_{rr} + \dots, \\ T_{or} &= A_1T_{1r} + A_2T_{2r} + A_3T_{3r} + \dots + A_rT_{rr} + \dots . \end{aligned}$$

Subtract the second line from the first, and there results

$$U_{or} - T_{or} = A_r(U_{rr} - T_{rr}); \text{ or, } A_r = (U_{or} - T_{or})/(U_{rr} - T_{rr}), \quad (107)_1$$

since, by the first of (106), all the remaining terms cancel. Thus, the rth coefficient equals the excess of the mutual potential over the mutual kinetic energy of the given state and the rth normal state, divided by twice the excess of the potential over the kinetic energy of the normal state itself.

The second and third of (106) give two equivalent relations, by widely different processes, viz.,

$$A_r = (Q_{or} + 4nT_{or})/(Q_{rr} + 4nT_{rr}), \quad . \quad . \quad (107)_2$$

and

$$A_r = (Q_{or} + 4nU_{or})/(Q_{rr} + 4nU_{rr}), \quad . \quad . \quad (107)_3$$

As the first of (106) is the easiest to remember, so it is in general the most readily applied, giving $(107)_1$. But some special cases should be noticed.

If there be no potential energy, but only kinetic energy and dissipativity; that is, in all problems in which dielectric displacement is not taken into account, as, for instance, any combination of conductors between which there is electromagnetic induction, but with no condensers, we have

$$c = 0,\ T_{12} = 0,\ Q_{12} = 0; \text{ and } A_r = T_{or}/T_{rr} = Q_{or}/Q_{rr}. \quad . \quad (108)_1$$

If there be no kinetic energy, but only potential energy and dissipativity; that is, in all cases in which electromagnetic induction is ignorable, as in any combination of conductors and condensers, but not coils, we have

$$\mu = 0,\ U_{12} = 0,\ Q_{12} = 0; \text{ and } A_r = U_{or}/U_{rr} = Q_{or}/Q_{rr} \quad . \quad (108)_2$$

If there be potential and kinetic energy, but no dis ipation,

$$k = 0,\ U_{12} = T_{12}; \text{ and } A_r = \frac{U_{or} - T_{or}}{U_{rr} - T_{rr}} \quad . \quad . \quad (108)_3$$

In this last case conductors are excluded. We have a strictly conservative system, from which all radical friction is excluded. It goes on oscillating for ever, but never does any useful work. We must therefore abolish it. A peculiarity connected with $(108)_3$ will be noticed in the next section. Also that the general properties (106) are true whether the rates of subsidence of the two systems be unequal or equal, although in the latter case special procedure is required.

The nature of the normal distributions themselves depends upon the distribution of c, k, and μ throughout space. We have

$$\text{curl}\,.\,H = (4\pi k + cn)E\,; \quad -\text{curl}\,.\,E = \mu nH\,; \quad . \quad (109)$$

in a normal arrangement. Hence, either E or H being found, the other follows. Thus, eliminate H to get the equation of E,

$$\text{curl}\ \mu^{-1}\text{curl}\,.\,E + n(4\pi k + n)E = 0 \quad . \quad . \quad (110)$$

Any solution of this is a normal E, and the corresponding H is definitely fixed by the second of (109). Not counting the simple cases of linear circuits and similar problems, (110) has been solved in three dimensions in a very few cases.

Presuming we have obtained the normal solutions, the question arises, what values of n shall we take? We must take all that satisfy all the conditions of the problem. One form of the determinantal equation, whose roots give all the admissible values of n, is the equation of activity itself,

$$Q + \dot{U} + \dot{T} = 0\,; \text{ or, } Q + 2n(U + T) = 0,$$

applied to the normal solutions. It is an equation in n only, with various constants, but independent of x, y, z, and t. That is, if in some special case of (110), we know the normal solution, we can find the equation of n by writing out the equation of activity extended over the whole system. But the equation of n is usually to be obtained from the boundary conditions, when the normal functions are known through bounded spaces.

If we extend our calculation of the excess of the mutual potential over the mutual kinetic energy of two normal systems through a bounded space, instead of all space, we shall obtain, not $U_{12} - T_{12} = 0$, but

$$(n_1 - n_2)(U_{12} - T_{12}) = \Sigma N(VE_2H_1 - VE_1H_2) \quad . \quad (111)$$

the summation being over the boundary, N being the unit normal drawn inward. Hence $U - T$ for a single normal system n is given by

$$U - T = \Sigma N\left(VH\frac{dE}{dn} - VE\frac{dH}{dn}\right). \quad . \quad (112)$$

There are of course corresponding boundary forms for the second and third of (106).

The general properties of normal systems (100), (102), (104), (106), (107), and (108), are not peculiar to the special dynamical connections which are involved in the electromagnetic equations, but belong to any dynamical system in which forces of reaction are proportional to displacements, and resistances to velocities, with reciprocal relations amongst the coefficients which are equivalent (in the electromagnetic case) to the three linear relations between forces and fluxes being of a symmetrical nature; or c, k and μ self conjugate, with no rotatory power. Conservation of energy requires this to be true for c and μ; and (106) are not true unless k be also self conjugate. But further remarks on normal systems must be postponed.

(To be continued.)

THE STEAM ENGINE INDICATOR.—X.*

BY AMICE.

Before proceeding to the condensing engine diagram, we will here give one from a higher type of high pressure non-condensing and, for the stroke, high speed engine, namely,

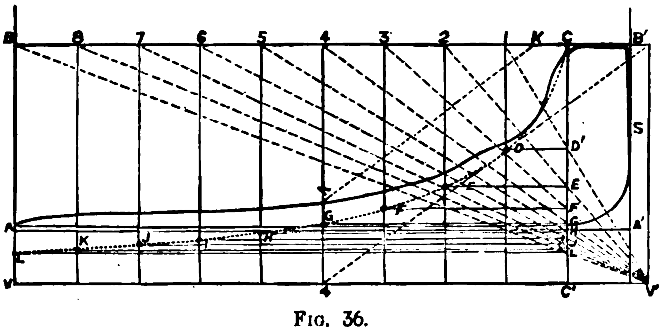

Fig. 36.

an Allen engine. It is given in this place merely to show the form of diagram which results from long range expansion, or, in other words, an early cut off. Fig. 36 is from an engine with an 8in. cylinder, area = 50·26, stroke 2ft., revolutions 150 per minute, and steam cut off at one tenth of the stroke, giving a ratio of expansion of ten. The engine was running light at the time the diagram was taken with a Richards indicator, and the back pressure, which is shown by the space between the lower line of the diagram and the atmospheric line A A′, was caused by the long length of exhaust pipe which was attached to the engine, aggravated by several bends. We have drawn an enclosing parallelogram about the diagram for the purpose of explanations, to which we shall recur later on. It will be seen that the steam admission line S departs from the vertical above S, showing that the full pressure was not realised until the piston had moved about a quarter

* For Art. 9, see *The Electrician*, 20th November, 1885.

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of an inch, the admission being somewhat restricted, there being practically no lead. At C the cut off took place, that is at the end of the first tenth of the stroke, and the pressure fell to one-half the maximum when the next tenth of the stroke was completed. From thence it falls gradually, until at the end of the stroke the pressure was 4·25lb. Exhaust then took place, but the pressure did not drop below 2·25lb., until the piston had made a considerable part of its return stroke, and never much below 2lb. At G the exhaust port is closed, and compression commenced. The valve gear of this engine is of a very quick acting kind, and cut off takes place without wire drawing. It will be remarked that the curve falls just above the letter D, forming a hollow curve. Between the division lines 1 and 2 the curve becomes convex, and afterwards again assumes the proper hollow expansion curve. The wavy line between or within the second and third divisions is caused by the oscillation of the indicator spring, and the inertia of the attached parts, both being brought into play by the sudden falls of pressure and correspondingly sudden movement of the indicator piston. There are other causes assumed to act to bring about this wave line, which is often much more pronounced than is here shown from an engine running at 150 revolutions per minute. We have not written upon this diagram the various pressures, as these figures would have confused an already filled diagram, but a measurement gives a mean pressure of 14·2lb. per square inch, the maximum pressure being 50lb. The piston rod being 1·75in. diameter gives an area of 2·4 square inches. As the rod only passed through one cover, we have to deduct only half this area from that of the piston, bringing it down from 50·26 to 49·06, or, say, 49 square inches. The indicated power of this engine was thus $\frac{49 \times 2 \times 150 \times 2 \times 14{\cdot}2}{33{,}000} = 12{\cdot}78$ horse-power.

Or we may simplify the figures by taking the piston speed in feet per minute and the power per lb. pressure. The piston speed being 600, we have $\frac{600 \times 49}{33{,}000} = 0{\cdot}899$, or, say, 0·9. The indicated power at the above pressure is then $14{\cdot}2 \times {\cdot}9 = 12{\cdot}78$.

We have drawn upon this diagram the theoretical curve of expansion according to Boyle's or Marriotte's law. It should, perhaps, be always called Boyle's law, as by him it was discovered in 1662, and afterwards verified by Marriotte, and is to the effect that the pressure of a gas at constant temperature varies inversely, as the volume of the space it occupies—that is to say that if p and v represent pressure and volume, then $p\,v =$ a constant. This is true for gases such as air, but it is not true for steam; but upon this assumption this so-called theoretic curve is drawn, and is very valuable for purpose of comparison. The curve is hyperbolic, and in practice is very nearly approached in consequence of conditions which come into play when steam is used to perform work expansively in a cylinder, as will be explained. For the present we may notice that our diagram shows pressures which from the middle of the second tenth part of the stroke are greater than the hyperbolic curve demands when the cut off is at C. This is in consequence of the re-evaporation of a very large quantity of steam, which is condensed in the first part of the stroke on its entrance into a cylinder cooled down to the temperature of steam at the end of the previous stroke, at about 4lb. The absolute pressure, as shown by the above diagram, at the end of the stroke, is 19lb., corresponding to a temperature of 225deg.; the temperature at the commencement of the stroke is that corresponding to a pressure of 76lb. absolute, or 308deg., the range of temperature being 83 degs.; but if the heat of the steam condensed in the commencement of the stroke did not provide the means of re-evaporation of the water in the cylinder, and of maintaining the temperature throughout the stroke, the pressure would fall at least as low as shown by the hyperbolic or isothermal curve in diagram 36, or to as low as 7lb.—really it would fall much lower. The temperature due to 7lb. pressure is 177 deg., or a range of 131 degs. The lowering of temperature of the cylinder consequent upon this range of temperature calls for the condensation of a large quantity of steam during the commencement of every stroke, and this being re-evaporated during the later part of the stroke under the falling pressure of temperature gives the steam pressure which keeps the indicator diagram high above the hyperbolic curve. Before leaving this diagram it may be pointed out that during a large part of the stroke the pressure is not sufficient to overcome engine friction, so that for this reason alone, apart from others of equal importance, it is clear that a range of expansion of ten is not an economical one.

Leaving this high-pressure non-condensing engine diagram for the present, we must turn to typical diagrams from high-pressure condensing engines as distinguished from the low-pressure condensing engine diagrams (Figs. 33 and 34) taken from the atmospheric engine referred to at page 11.

First, we must deal with the diagrams from a Cornish engine. Not because these are often met with now, and at any time only as pumping engines, but because the Cornish engine diagram is peculiar; and our articles would be incomplete without a brief reference to this, the most important, form of single acting condensing engine. It must be premised that the steam only does direct work in the down stroke of these engines and on the top of the piston; but indirectly it does work by condensation on the lower side of the piston. The weight of the pump rods and buckets is sufficient to pull the engine beam down at the pump end, and, of course, up at the engine piston end. No steam is thus directly required to raise the piston. The working of the engine is as follows:—Steam is admitted to the top of the piston, and is cut off earlier or later according to the load; when the piston is at the bottom of the stroke a valve affording communication between the two ends of the cylinder, and called the equilibrium valve, is opened,

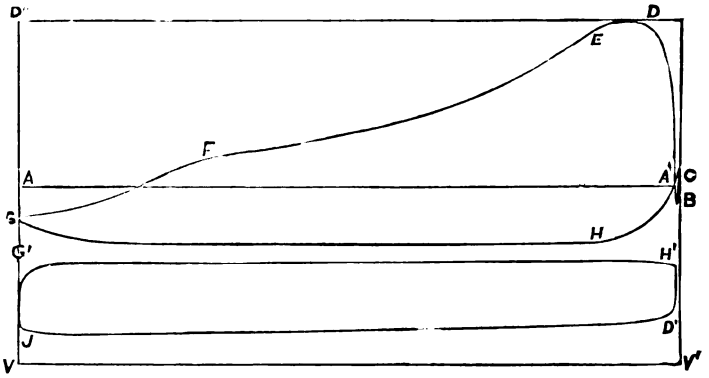

FIG. 37.

and the steam from the top of the cylinder is thus free to pass to the bottom. Equilibrium is thus established between the top and the bottom of the piston, and the piston is lifted by the beam, all the steam passing to the under side of the piston as it leaves the upper, and the pressure falling somewhat. When the piston is at the top of the stroke the equilibrium valve is closed, and a valve communicating between the lower side of the piston and the condenser is opened, the steam is condensed, and a vacuum formed. At the same time the steam valve is opened to the top of the piston, and the down stroke is performed by steam pressure at the top of the piston and by vacuum beneath it, or by atmospheric pressure added to the steam pressure acting on the top of the piston. The diagram obtained from such an engine is given in Fig. 37. In this diagram, which is given full size as taken, the scale being one-sixteenth inch to the inch, A A′ is the atmospheric pressure line, V V′ the line of absolute vacuum. Tracing the pencil we may follow the piston in its downward stroke. Steam is admitted and the pencil rises from A A′ to D, one-twentieth part of the stroke being performed before the maximum pressure is reached, owing to a somewhat restricted steam passage or slow valve. The piston descends, steam is cut off at somewhere near E, and expands down to F, when the equilibrium valve begins to open, and the pressure falls to G. At this point the equilibrium valve is full open and the piston begins to rise, the steam passing from above it to below it as it does so, and the line G H is traced from the top of the cylinder, while the line G′ H′ is traced from the lower end, the gap between the two lines representing loss of pressure in the communications between the two ends of the cylinder. When the

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piston reaches the top of the stroke, not only is steam admitted, as before, to the top of the piston, but the exhaust valve opens and the steam from below rushes into the condenser, and the pencil falls from H′ to D′. The down stroke is now made under the pressure H D + H′ D′, and (with an indicator at either end of the cylinder) the lines A′ D E F G and D′ I are simultaneously drawn. It will be noticed that in the up-stroke the equilibrium valve closes at H before the stroke is completed, and the steam imprisoned on the top of the cylinder is compressed, as shown by the curve H C. The compression increases the pressure, and carries the pencil to C, but as soon as the piston stops, loss of heat by conduction, radiation, and leakage causes the fall of pressure again to B before the new steam enters, and hence the loop C B. When pressure has fallen to B, new steam enters, and the pencil rises as before to D, and the operations recommence.

Our space compels us to leave the high-pressure, double-acting, or ordinary condensing engine diagram until next week.

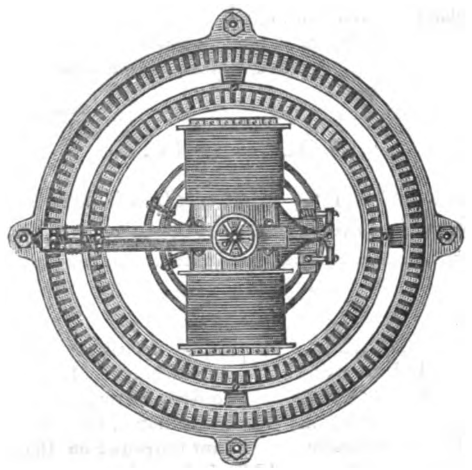
ELECTRIC HAULAGE.

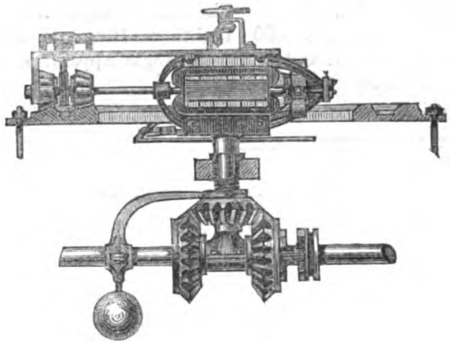
Within the last few years, almost within the last few months, we have had many schemes of electric locomotion before us, some of them depending upon the practical transmission of electrical energy over short distances, while others have been the outcome of comparatively recent improvements in storage batteries. In the majority of cases this new method has been applied either to the propulsion of launches or other small boats or to the haulage of tram cars, and in this latter direction some degree of commercial efficiency has been arrived at. As regards the merits of the various ways in which the current is conveyed in each case to the electro-motor opinions differ. Direct driving—the rails being in the dynamo circuit—has its disadvantages during very wet weather, for there *must* be an appreciable loss, however carefully the insulation of the line is attended to; the overhead conductor is a nuisance, and the use of accumulators—a method which seems to us to bear the greatest promise—is restricted, or, rather, delayed by the unfortunate fact that the accumulator is but ill adapted for the purposes to which it is applied. In other words, speaking from a commercial point of view, the storage battery must undergo radical alteration before any decided advance is made in the direction of electric locomotion. It is always interesting, however, to learn that a step forward has been made by any one of the many workers in this field, and the chronicling of such an event is a task which to us is always a grateful one.

Within the last few days we have been enabled by the courtesy of the Electric Locomotive and Power Company to inspect a new tram engine now being experimentally used at the North Metropolitan Tramway Company's depôt at Stratford. This engine has been contrived by Mr. C. P. Elieson, and is one of the happiest combinations of electrical and mechanical power that we have seen. It is novel and yet it is not novel—a paradox and an excellent invention. The novelty consists of the mode in which the power is transmitted to the driving axle—in the fact that the motor itself revolves, and in the substitution of a mechanical clutch for the electrical reversing gear hitherto adopted. The want of novelty is present in the motor, which is of ordinary construction, with a link armature; and in the secondary cells, of which there are 50 (E.P.S.), giving 280 ampere hours and rather over 100 volts. The mechanical connection of the motor is very ingenious, in that Mr. Elieson has done what we may fairly suppose that Archimedes would have done had he lived in these days of enlightenment. He has applied a lever between the electro-motor and the axle of the locomotive in such a way that the motor, which must necessarily run at a high rate of speed in order to develop the greatest efficiency, acts through the lever by a method analogous to the case of a man using a crowbar for the purpose of lifting a heavy weight. By this contrivance the *vis inertia* of the loaded tram car is easily overcome, and it is evident, even to non-scientific readers, that speed is then easily attained until the natural speed of the electro-motor is approached by the rate of speed of the driving wheels.

Instead of the electro-motor being a fixture, and having motion transmitted from it through belt or crank gearing to the wheels of the car—a method which involves loss of power, and necessitates the provision of ample space—the motor itself revolves, the motion being transmitted through bevel gearing. It has, as will be seen by our illustration, a vertical shaft through its centre, to which a motion lever projecting horizontally about 2ft., and carrying at its outer end a spur-wheel gearing into a fixed circular rack, is secured. This vertical shaft carries at its lower end a bevel wheel, which gears into one or other of two similar wheels on the driving-axle of the engine. The mitre gearing is equipped with a mechanical clutch, by means of which the engine may be made to run either backwards or forwards; a lever, acting mechanically, throwing the motor in or out of gear, or adjusting the clutch by a simple movement of the hand. This suggests itself to us as being a very good arrangement indeed. In the first place there is a minimum loss of energy, in that the motion being applied direct to the axle there is very little energy wasted in friction, &c.; in the second place the motor, always travel-

Plan.





Elevation.

ling in the same direction, and being above the floor level of the car, it is subject to fewer strains and fewer losses than is the case when reversals are made and when the motor is placed below the floor level, and therefore during wet weather in nearer proximity to a source of leakage; and, in the third place, there is due to the lever a decided gain of power at the moment when it is most wanted, *i.e.*, at starting. The electrical details are very simple. The motor is fitted with collecting brushes travelling on two fixed circular rings of copper, separated from each other by a flange. The speed of the motor is varied by inserting resistances in the ordinary way, and it is evident that great care has been exercised to avoid anything like complexity. The locomotive in appearance resembles a small car, and weighs 4 tons 17cwt. The motor, which is of four horse-power, consumes about 40 amperes per hour, so that it carries power sufficient for seven, say six, hours of motion, and makes about 700 revolutions per minute when in full swing, or a maximum of 1,000 on a level road. The speed obtained is eight miles per hour, it being for certain obvious reasons not desirable to exceed this rate.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XV.

Volume XV. of "The Electrician," price 10s. 6d., is now ready. Also cases for binding, price 2s.

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THE SOCIETY OF TELEGRAPH-ENGINEERS.

After each recurring annual meeting of this Society for several years past we have thought it right to comment upon the manner in which its election of officers has been conducted. At first we tried protest, then argument, and lastly ridicule. No impression that we know of has been made by any of these methods. This year, therefore, we propose trying another, namely, to say what we have to say beforehand, so that there may be no excuse for acting through inadvertence or forgetfulness. One of our complaints has been that the Society does not notify to its members that the election of its Council is impending in time for them to offer any candidate of their own, or to consider the merits of the nominees submitted for their approval. We will supply this defect on the present occasion, by reminding our readers who are members and associates of the Society that the annual meeting is fixed for the 10th December, when the election, as it is called, of the Council for the ensuing year will take place. If precedent is followed, there will be no notification of this fact from the official source until a few days prior to the event; and as regards the persons to be elected, their names will be posted on the day of the election, or possibly the day before. The form on which this information is conveyed will contain just the number of persons to be elected and no more, and just the names preferred by the Council and no other. If any different course is pursued on the present occasion we shall be glad to give the Council all the credit of it. They have taken so little notice of our complaints hitherto, that anything they may do now, good or bad, will of course be due to themselves, not to us.

In truth we address ourselves now to the electors rather than the Council or the Council's candidates. From members and associates, who, for the subject in hand, are nominally the elective body of the Society, we have frequently heard disparaging remarks on the conduct of the election—remarks much stronger than any we have ever yet used in regard to it ourselves; and we confess to symathising with their complaints to some extent, and entirely condole with them on the ridiculous figure they are required to cut on the occasion of the so-called Balloting. The Ballot Box ought to tell the same tale. If our own eyes have not deceived us the number of papers deposited in the sacred urn have grown fewer and fewer every year; and none but innocent young men, or casehardened old ones, now think it worth while to make the solemn journey, paper in hand, down the gangways in order to ratify a conclusion which has been already settled elsewhere. It must be as hard for the Council to keep their countenance while this empty function is being enacted as it is for the electors to keep their temper. We hear just now a good deal about voting for the "ticket;" but we never heard of the wires being pulled by any political or scientific caucus when there was positively no opposition. Here the ticket is drawn up and the wires pulled, just as if the "will of the nation"—or, rather, the wishes of the members—were being consulted and weighed in real earnest. And when this formal make-believe is repeated year after year it does not surprise us that some of the spectators get impatient, and begin to ask whether it would not be better to dispense with the formality altogether, seeing that its retention is a waste of time at the best, and at its worst perpetuates the fiction that members and associates of the Society have a voice in the selection of its governing body.

Our own view, however, is not that the ceremony should be done away with, but that it should be made into a reality; or, at all events, that the event should be arranged so as to shift the unreality to the members themselves. At present the conduct of the whole business from beginning to end has the appearance of superseding the choice of the members and taking pains to hinder its exercise. We say it has this appearance; and quite needlessly we think. The power of exercising their privilege ought to be retained by the Society as a body, for it might be useful some day. But if events have proved that the right is seldom or never used, there is all the less reason for the Council to delay their nominations, or to forbear apprising the members of their rights in due time. The "ticket" of the Council is uniformly accepted; it generally would be accepted even if ample time were given to challenge it. But something more than this might be done; surely it is not impossible to select and submit more names than are actually required. This, whenever practicable, would relieve the Council of the imputation of dictating a hard and fast programme, which cannot be disputed without virtually passing a vote of censure on the framers, which no one wishes to do.

No doubt there are difficulties—some practical, some sentimental—which members are not perhaps so well aware of as they might be. It is well that the governing body should maintain its continuity by electing only men who will be likely to work with them on the same lines, men who will do credit to the Society, and who, in their turn, if otherwise eligible, will fill the positions of President, or Vice-President, with dignity and understanding. The haphazard choice of the members

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might conceivably fall upon a wrong man; but it would be the fault of the Council if it did. It is not their fault, however, that eligible candidates refuse to be nominated if they are to be subject to the risks of an election. The risk, as we have already hinted, is very small, or may be rendered so; but if a distinction is to be conferred it is none the worse for being given by vote, and the man who will not face it is not wholly deserving of it. We think this would be the general opinion of the elective body; aud it would do the weak-kneed gentlemen who decline a popular test of this very mild sort no harm to be informed of the fact. Still, no doubt the difficulty is in some instances a real one, and every allowance should be made for the delicate position in which the Council is occasionally placed. What we would urge upon it is, not to yield to the prejudice or the pride—whichever it may be—of these scientific top sawyers too readily; and, above all, not to be tempted into a false position with the Society as a whole in order to secure the services or spare the susceptibilities of any one man. It is right and proper that the Council recommend their successors in office; but whenever practicable they should leave some choice of selection for the members, and in any case should make a decent show of affording opportunity for them to exercise their undoubted right to nominate, if they are so minded. There would be time enough to correct it if any harm were threatened under such a system—which, however, is not at all likely.

CORRESPONDENCE.

THE SOUDAN CAMPAIGN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am much interested in the account of the use of the telephone for military telegraphing by Major-General Webber, and your remarks on this point in your leader.

I have been engaged in devising a regimental telegraph plant for the Queen's Edinburgh Rifle Volunteers Brigade, which I command, and propose to use the telephone both as transmitter and receiver. When transmitting in the field the telegraphist will rub the mouth of his telephone round and round on a roughened disc hanging from his belt at the left side, and make and break contact by a commutator attached to his belt at his right hand, thus producing the Morse symbols. Mr. Preece and Prof. Blyth are kindly making experiments for me to test the feasibility of the suggestion. There can be no doubt that it would be a great gain in field telegraphy if we could get rid of all cumbrous batteries with their weight and bulk, and their liquids and chemicals, which climate and accidents so easily injure. But there is a further and military advantage by which I set great store, viz., enabling each battalion to carry its own telegraph appliances without horse transport. This would be a great advantage, as the present system of a separate telegraph corps, working with heavy waggons, is most unsatisfactory. It necessitates the telegraph plant for large bodies of troops being concentrated in great quantities, and the laying out of it being not done in sections, but in a long line. This is inconsistent with rapid laying and rapid picking up. Besides, it prevents all use of the telegraph for sectional purposes, if I may use the term. Would it not be a most useful thing if regiments sent on outpost duty could run out a line from their main body to their advanced posts, and thus communicate freely and rapidly? Besides, in modern war it is very important to have telegraphists as part of the interior economy of the smaller units of the service. At any moment in war the presence of a telegraphist may be useful. Such a measure as tapping an enemy's wire, if you come on it, can only be done if you have a telegraphist available. But last and not least, can it be doubted that the presence of telegraphists with each battalion would greatly facilitate the establishment of communication at the end of the day's march of an army? Each battalion would at once lay its cable along its rear, coupling on to the next, and thus in a few minutes whole brigades and divisions would be in communication, where under the present system the telegraph corps might take hours before they could run out their cable from its four-horse waggon.—Yours, &c.,

Edinburgh, Nov. 21st, 1885. J. H. A. MACDONALD.

A PHENOMENON OF CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The experiment described (p. 35) by "An Electrical Student" is interesting, and resembles, in principle, one which I think has been described by Prof. Forbes. The results are in exact accordance with what I should expect upon the principles I laid down Nov. 6th, p. 485, Vol. XV. It may be well to explain this, because I there said that I should expect the closing of the secondary circuit to *reduce* the primary current, while these experiments show that it was increased. The reason of this apparent contradiction is that I was reasoning about the action with a current, *intermittent, but always in one direction*, while the experiments were made with an *alternating current*. Now, my principles would result in a diminished primary current with an intermittent but uniform E.M.F., and in an increased primary current with alternating E.M.F., as a consequence of closing the secondary circuit.

The same principle gives the opposite results, viz., that work has to be done in the secondary wire in producing the current.

With a merely intermittent current the E.M.F. generated in the wires, primary and secondary, at the moment of break is in the same direction as that of the generator; therefore, anything which prolongs that current and prevents the complete loss of the magnetism of the core is a help to the incoming primary current, or in other words diminishes the call upon it for fresh energy to re-magnetise the core. Closing the secondary circuit facilitates the de-magnetisation, therefore is work put upon the E.M.F., and reduces the current in the primary.

But with an alternating current any such residual energy, current, or magnetism *opposes the next entering current*. Hence we find that the introduction of a coil of wire in the circuit of generator and lamps reduces the current and light by its so-called "self-induction," and increasingly so when the core is inserted. In fact, at each alternation the current has to expend energy, not only in remagnetising the core, but also in driving out an opposing magnetism, so that the E.M.F. of the generator meets a counter E.M.F. in the coil.

Now, if the secondary circuit is closed, an outlet is at once provided for this reverse E.M.F.; it can do work in the secondary. Of course this work is taken from the primary circuit, the current of which is therefore reduced from what it would be if the coil were absent, but greater than it would be with the coil present and the secondary ciruict open—in fact, we may regard the closed secondary as a short circuit for the opposing E.M.F.; but it no longer acts *in the primary circuit* as an opposing E.M F. as well as a resistance. It is got rid of in the secondary wire as a current, and may be utilised, while if the secondary is absent it blocks the primary circuit, and appears as heat in the core and wire of the coil.—Yours, &c.,

J. T. SPRAGUE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The class room experiments mentioned (p. 35) by "An Electrical Student" have, to say the least, a very close connection with the phenomenon which you kindly allowed me to bring forward for discussion, and accordingly I am for my part much indebted to him for the contribution. One's idle self is tempted to think that Mr. Kennedy's results settle the question, but considering that his alternating currents are not precisely the same thing as the intermittent currents at work in my own case, I must accept the duty of experimenting imposed on me by Mr. Sprague. As regards other parts of

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Mr. Sprague's letter (p. 485, Vol. XV.), I hesitate to deal with his argument at present, as I feel the incompleteness of my own ideas in what I might say to it upon an orthodox basis. I am reading through Mr. Sprague's book, which I have just now added to my library—a very striking work. And while my preparations, mental and manual, are going on, I am very glad that others are interesting themselves in the subject, which one may thus hope to see fully elucidated. May I add that if there are any whose interest shrinks from expressing itself in public print, it will be a privilege to me to hear their opinions by private letter.—Yours, &c.,

E. ALDRED WILLIAMS.

37, Burlington-road, W. Nov. 21, 1885.

HIGH-SPEED ENGINES AT THE INVENTORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In a letter by Messrs. Crompton and Co., published in your last impression, there are the following sentences:—"We ourselves feel the utmost confidence in supplying to our customers dynamo machines driven directly by Willans' engines at speeds not exceeding 550 revolutions. We mention this limit because we think it is only fair that it should here be publicly stated that one of our dynamos, driven by a Willans engine at this speed of 550 revolutions, supplied the current, &c." There is no mistaking the figure. It is 550 revolutions a minute all during the time of the Exhibition, and not a single break down. This is gratifying to the maker of the engine and interesting to a humble student like myself, who is always glad to get reliable information straight from the fountain head. Most of my information on electrical matters I get from your pages; but sometimes I look also to your non-electrical contemporaries for useful data, and then I get sorely puzzled, as in the present instance. For on turning to *The Engineer* of June 26th I find it equally publicly stated that the speed of the Crompton dynamo at the Inventories was 450 revolutions a minute. I know now that the writer of the article in *The Engineer* must have been in error, and it is unfortunate, but excusable, that Messrs. Crompton and Co. did not correct his mistake at the time. I say excusable, because all makers of dynamos are proud of low speeds, and if a gentleman of the press takes it upon himself to make a particular dynamo appear better than it really is by reducing its speed by 100 revolutions, why, it is his business and not that of the maker. I am glad Messrs. Crompton and Co. have by their letter eliminated what scientists call the personal error, but there is still something I cannot understand.

According to *The Engineer*, the dynamo in question has an armature core 12in. in diameter, 28in. long, and contains 120 turns of wire. How is it that this machine required to be driven at the high speed of 550 revolutions a minute, when another dynamo erected at Buckingham Palace, with the same size armature core, but having only 96 turns of wire on it, produced the same electromotive force at only 440 revolutions? Messrs. Crompton, who are the makers of both these machines, will perhaps explain, and thus confer an intellectual benefit on A PUZZLED STUDENT.

LIGHTING WITH PRIMARY BATTERIES.

On Wednesday we witnessed the lighting of several rooms by incandescent lamps which obtained the required current from Ross's primary battery. Mr. Clarke, of 27, Queen's-gate, when fitting up his house was struck with the beauty and the cleanliness, not to mention the healthiness, of the electric light, and he determined to supplement the gas with electricity. The chandeliers in the dining room, drawing room, hall, &c., were modified so that the wires could be taken to incandescent lamps placed alternately with gas lamps. Unfortunately, the designer of the chandeliers is unknown to us, but whoever he is he deserves great credit for the elegant production to be seen at Queen's-gate. The lamps used are 10 candle-power nominal. The current is supplied by four 13-cell Ross batteries kept in the coal cellar. The batteries are connected, two parallel, so that they form two batteries of 26 cells each. Several of the cells were not in use at the time of our visit. A simple arrangement is made for the drawing off the used-up liquid and filling with the active liquid. This work has to be done each day, the quantity of active liquid used to replenish the cells being proportional to the number of hours the lamps have been lighted the preceding night. The exhausted liquid is drawn from all the cells simultaneously by means of glass tubing and flexible rubber connectings. The refilling of the cells is managed by the same apparatus. There has never been any denial as to the possibility of using primary batteries for the electric light, the only question in consideration being that of cost. The manufacturers of this battery, Messrs. Hunter, Harrison, and Co. state that its first cost is low, the cost of working does not exceed, and is in many cases less than that of gas: it requires but little and only unskilled attention; it can be absolutely relied on, and is of course noiseless. The following is the report of Dr. John Hopkinson, F.R.S., on the Ross primary battery:—"Its constancy with a large current is remarkably good; the method of drawing and replenishing the liquids is very convenient. The form in which the carbon electrode is arranged is an advantageous one, and the liquids used in the cells are less expensive than in any battery having any pretence to constancy."

REIS'S ACOUSTICAL TELEPHONE.

(*Continued from page 18.*)

Assuming, for the sake of argument, the correctness of the explanations generally given as to the manner of operation of, say, any of Edison's contact transmitters, the explanation would be as follows, viz.: The sound waves impinging on the diaphragm impart to it vibrations similar, in their movements and complexity, to the vibrations they would also produce in the ear of a person standing near the speaker. The movements so produced in the diaphragm vary the pressure of the contact points and cause corresponding variations in the electrical resistance of the circuit in which the variable-resistance contact points are placed. These variations acting on the magnetic receiver at the receiving end of the circuit, reproduce in its diaphragm the motions of the transmitting diaphragm, so that one listening at the receiving instrument hears whatever sounds are made at the transmitting instrument.

In order to avoid the too great movements of the contact points, by means of which one of them would be thrown completely off from the other, *and thus be prevented from receiving the impress of the movements of the diaphragm while it was separated from it*, one or both of the contact points are mounted on springs, the pressure of which against the other point on the diaphragm is controlled by regulable screws. When properly adjusted, the contact point follows the motions of the diaphragm, and instead of actually leaving it completely and entirely, only leaves it at certain points of its surface, thus varying the cross section of the conducting surfaces in contact, and, of necessity, their electrical resistance.

If it were a matter of indifference whether the contact point occasionally left the diaphragm long enough to prevent it from receiving the impress of all its to-and-fro movements, the regulating screw would be unnecessary. The presence of this screw, when taken in connection with the elastic support of one of the contacts, would appear clearly to show that the inventor intended, when he produced such a mechanical structure, to avoid the too free movement of the contact; that he intended the contact to be influenced by all the movements of the diaphragm; that he desired especially to avoid such a free movement of the contact point as would prevent it from leaving the diaphragm for such a length of time as to cause it to miss some of the to-and-fro movements of the diaphragm.

In the Berliner transmitter, the weight and inertia of the swinging contact permits the suppression of the elastically-mounted contact and its adjusting screw. In the Blake transmitter the elastic support is given to both contacts, their weight and inertia permitting the suppression of the adjusting screw.

Applying the preceding description of the mode of operation of Edison's, Berliner's, and Blake's transmitters to sketches 1, 2, 3, 4, and 5 of Reis's transmitters, we fail, after careful thought, to perceive any differences in their mode of operation. Their

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mechanical structure and the relative arrangement and proportion of their parts are practically the same. The action of the sound waves on the diaphragm and its action on the contact points are the same, so that, whatever one does, the other does ; whatever one is, the other is.

Now, in considering the only fair and proper meaning to attach to Reis's use of the words "make" and "break," we would call attention to the following important points, viz., that where necessary to prevent such makes and breaks as would be injurious to proper action, we find in all of Reis's transmitters :

1. Elastically-supported contact points.
2. Regulable screws provided for varying as desired the pressure of the contact point against the diaphragm, and that, moreover, when such devices are unnecessary, as No. 5, they are markedly absent.

In view, then, of these facts, clearly shown by the mechanical structure of his apparatus, we find it difficult to understand how any one is willing to maintain that Reis intended that the "makes" and "breaks" he alludes to in his description of the theory of operation of his apparatus were of such a nature as to produce such a free movement of the variable contact point *as would throw it completely off or away from the diaphragm, so as to cause it to lose some of its to and fro movements.* That such was never intended is not only proved by the elastically supported contact and its regulating screw, but also by the direct statements of the inventor. He speaks thus of the contact: "The little hammer-shaped wire *d* being pushed back" at each condensation, which would be clearly impossible if it lost some of the condensations. He asserts that "the movable angle (of his cabinet apparatus) will be lifted up and will thus open the stream at every condensation of air in the box ; the stream will be re-established at every rarefaction."

That Reis could not have intended his use of the words "make" and "break" to signify such a separation of the elastically-supported contact as would remove it from the diaphragm long enough to permit it to miss some of its vibrations, should need no further proof than a careful study of the very able manner in which he discourses, in his *Jahresbericht* article, the graphic representation of the alternate condensation and rarefaction of the air in sound-waves. His insight into this matter was remarkably clear, considering the time at which he wrote, and even the most advanced science of the present day has but little to add to what he has stated as to the representation, by means of graphic curves, of the variations in the density of the air produced by means of sound-waves. His writings show, in the clearest manner, that the prime condition he constantly kept before him, in order to solve the electrical transmission of sounds of all kinds, was the necessity of obtaining an exact reproduction, in the diaphragm of the receiving instrument, of the movements of the diaphragm of the transmitting instrument under the influence of the sound-waves. "The function of the organs of hearing, therefore, is to impart faithfully to the auditory nerve every condensation and rarefaction occurring in the surrounding medium." "That which is perceived by the auditory nerve is, therefore, merely the action of a force affecting our consciousness, and as such may be represented graphically, according to its duration and magnitude, by a curve." "Our ear can perceive absolutely nothing more than is capable of being represented by similar curves, and this method is completely sufficient to bring before our clear consciousness every tone and every combination of tones." "As soon, therefore, as it shall be possible, at any place and in any prescribed manner, to set up vibrations whose curves are like those of any given tone *or combination of tones* (the italics are my own), we shall receive the same impression as that tone or combination of tones would have produced upon us."

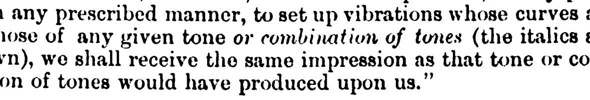

FIG. 15.—Graphic Representation of Condensation and Rarefaction.

"Taking my stand on the preceding principles, I have succeeded in constructing an apparatus by means of which I am in a position to reproduce the tones of divers instruments, yes, and even, to a certain degree, the human voice."

Can any reasonable doubt remain, after reading the above, that Reis could have intentionally designed his apparatus to produce effects contrary to what he so clearly stated as necessary for its success ? This will, perhaps, be made still clearer from an inspection of the tables of curves accompanying his *Jahresbericht* article. These we will reproduce, as well as a translation of that part of the article alluding to them, even though we have quoted some of it previously. We will use for this purpose the translation introduced into the record of the "American Bell Telephone Company *v.* Amos E. Dolbear, *et al*" :—

"What our auditory nerve perceives is, then, simply the effect of a force coming within the range of consciousness, and this force can be represented, both as to duration and magnitude, graphically by a curve."

"Let *a*, *b* (Fig. 15) represent any given time, and the curve above the line condensation (+), the curve below the line rarefaction (−), then any ordinate raised from the end of any abscissa will represent the degree of condensation at the time represented by its base, in consequence of which the drum of the ear vibrates.

"Our ear can, under no circumstances, appreciate more than can be represented by these curves, and this, indeed, is entirely sufficient to give us a clear perception of any tone (*Ton*) or any combination of tones.

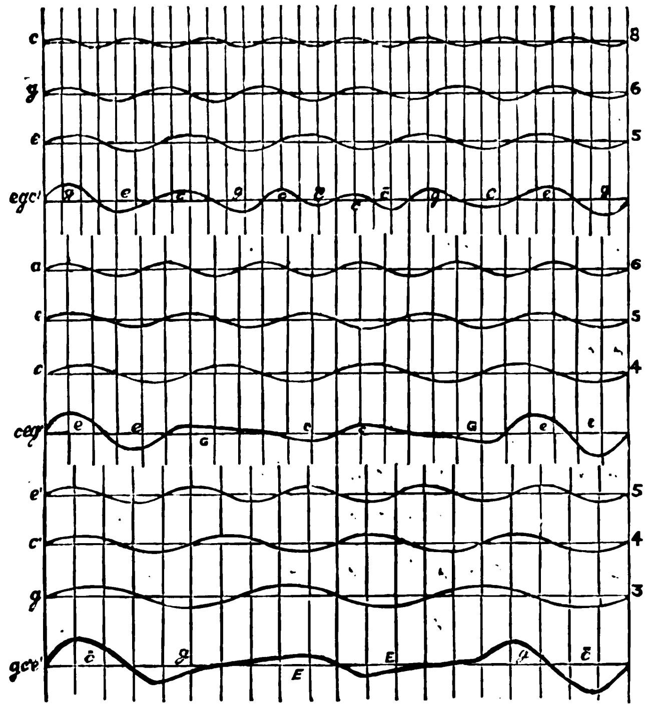

FIG. 16.

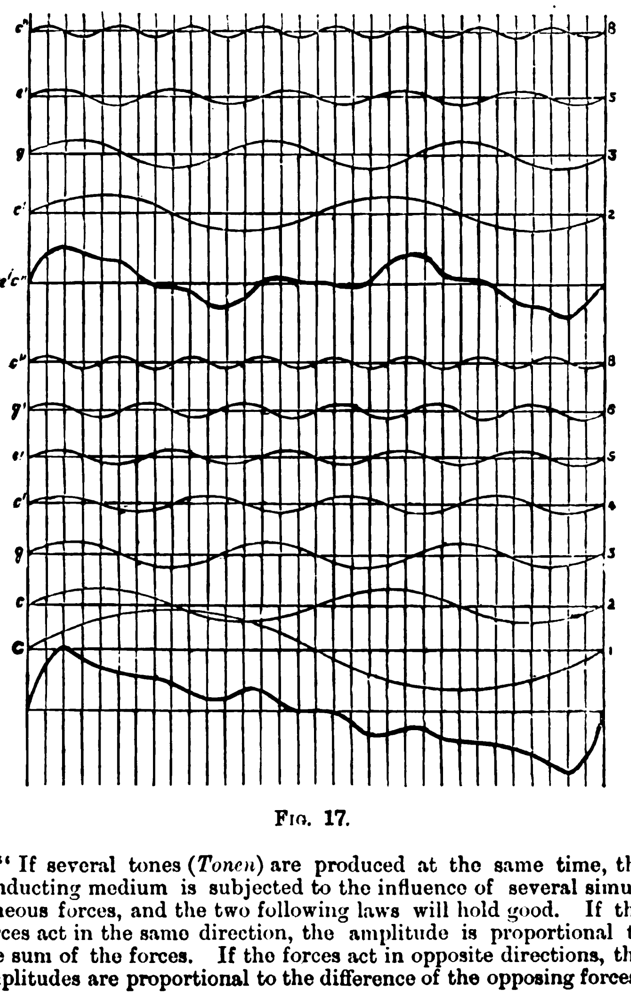

FIG. 17.

"If several tones (*Tonen*) are produced at the same time, the conducting medium is subjected to the influence of several simultaneous forces, and the two following laws will hold good. If the forces act in the same direction, the amplitude is proportional to the sum of the forces. If the forces act in opposite directions, the amplitudes are proportional to the difference of the opposing forces.

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"If, for example, in the case of three tones, we draw the curve of condensation of each separately, then by a summation of the ordinates of corresponding abscissæ we can determine new ordinates and develop a new curve, which might be called the combination curve. This represents exactly what our ear perceives of the three simultaneous tones. The fact that the musician can distinguish the three tones need not surprise us any more than the fact that any one acquainted with the theory of colours can in green discover blue and yellow ; but the combination curves in Fig. 16 show that this difficulty is a slight one, for in these curves all the relations of the components successively recur. In the case of chords, of more than three notes, the relations are not so readily seen from the drawing, Fig. 17, for example. In the case of chords, however, the skilled musician also finds difficulty in recognising separate notes.

(To be continued.)

SOCIETY OF ARTS.

We extract the following remarks from Sir F. Abel's Presidential Address, inasmuch as they bear more or less upon the development of electricity in lighting matters :—

There are some mines so free from fire-damp that naked lights, in the form of candles or oil lamps, may be used therein with perfect safety as illuminating agents, and others where the occurrence of fire-damp being confined to some few localities, the use of safety lamps need apparently be only insisted upon in certain parts of the workings. There can be no doubt, on the other hand, that the adoption of even the most perfect ventilation cannot secure such absolute safety as to render the use of naked lights warrantable where seams are worked in which fire-damp exists in any abundance, because danger may there arise at any time, from some accidental stoppage or partial failure of the ventilating arrangements, from the effect of a reduction of atmospheric pressure in promoting the escape of gas from lurking places, or from a liability to the sudden emission of gas in considerable quantity from coal, to which reference will presently be made. The very poor light furnished by the forms of safety lamp still chiefly in use, and the consequent increase in the difficulties of working and in the risk to which the miner is exposed from sudden falls of coal or stone, have afforded very strong temptation to the men who have recourse to naked lights, and to the managers of mines to regard such proceeding with indulgence, even where its danger is well recognised. The strongest incentives have, therefore, existed to the application of inventive and constructive ability, either to the improvement of the light furnished by existing forms of safety lamps, or to the production of new forms of lamps presenting decided superiority over them in light-giving power.

It is, however, not only in this direction that the miners' lamps have needed and received improvement ; the poor light furnished by the older forms of lamps in a quiet atmosphere becomes even much worse when they are exposed to such currents as are now met with in properly ventilated mines. In order, therefore, to afford that advantage over naked lights from the simple point of view of efficiency for working purposes, which shall tend to secure its preference over these, the lamps should burn brightly and steadily even in strong currents of air. Lastly, though first in order of importance, the lamp should be unable, under any circumstances at all likely to arise in coal mines, to ignite an inflammable or explosive mixture of fire-damp and air, even when this is passing at the highest velocities which can occur in any part of a mine.

The importance of determining how far modifications of existing lamps, or new kinds brought forward from time to time, fulfil the latter condition, has led individuals specially interested in the subject, and associations of mining engineers, for many years past, to submit lamps to comparative experimental tests ; and the first branch of inquiry which was taken up by the Royal Commission, and which has been steadily pursued by the members up to a quite recent date, was the systematic comparison of the behaviour of different lamps in currents of explosive mixtures of gas and air, travelling at different and accurately-determined velocities. More than 200 different lamps, partly received from various manufacturers and inventors in this country, and partly from France, Belgium, and Germany, have been submitted to tests in explosive atmospheres, under variously modified conditions, representing, as far as possible, every variety of cirumstances under which the lamp might be employed in a mine. Collateral experiments have been made upon the relative merits in point of safety and efficiency of different illuminating agents susceptible of employment in safety lamps. The experiments have been carried out by the Commission, partly at particular collieries in South Wales and Lancashire, where natural blowers of fire-damp, which are piped to the surface, furnished the supplies of gas with which the tests were made ; and partly at Woolwich Arsenal, where special facilities were furnished for accurate and extensive experiment.

The results of these extensive investigations will now very shortly be in the hands of the public, and I must not presume to do more than indicate their general nature.

Until within a comparatively recent period, only three types of lamp were in extensive use in this country—the original safety lamps which the miners owe to the genius of Davy and of Stephenson, and a lamp not long afterwards devised by Dr. Clanny. When the safety lamp was first invented, the ventilating currents in mines were very moderate, seldom attaining a velocity of even 5ft. per second in the principal roads or air-ways, while in the working places themselves the currents were very slight. The Davy, Stephenson, and Clanny lamps were safe under these conditions in the presence of fire-damp. But at the present time air currents in the main roadways of mines often travel at a rate of 20 to 25ft. per second, and at the working places their velocity ranges from 5 to 15ft. per second. Moreover, it is even possible that under special conditions, which may obtain in particular parts of the mine, current velocities of 30 to 35ft. may be met with. Under conditions such as these, the Davy and Clanny lamps cease to afford any security, and it has been demonstrated by the experiments of the Commission that even the Stephenson lamp, which is generally extinguished by an atmosphere highly charged with fire-damp, may bring about an explosion in currents of fire-damp and air. These facts had already been indicated by the results of previous experiments when the Commissioners commenced their work, but their own investigations so clearly established the great danger of relying upon the Davy and Clanny lamps, and the facts already known on the subject appeared to have received so little attention on the part of managers of mines (great confidence in the safety of those lamps having even been expressed by experienced witnesses), that the Commissioners considered it their imperative duty to direct the attention of the Home Secretary to the fact "that the employment of the ordinary Davy lamp, without a shield of metal or of glass, in an explosive mixture, when the air currents exceed 6ft. a second is attended with risk of accident almost amounting to certainty," and that "the Clanny lamp, when tested in a similar current, has proved to be scarcely, if at all, less dangerous." They hoped that the most prominent publication would be at once officially given to this warning. After some delay a circular embodying the substance of it was issued, but without any indication that it bore the authority of the Royal Commission. This action was taken as far back as December, 1880 (they having been appointed early in 1879), yet the Davy and Clanny lamps have continued in use in mines where the elements of danger insisted upon by the Commissioners exist.

The Davy lamp had some years back been rendered much less dangerous when exposed to strong air currents by the addition of a metal shield partially surrounding the gauze cylinder, or by the provision of an external glass cylinder extending up the gauze to various distances. The latter modification, known as the Jack lamp, if properly carried out, proved to be the most efficient safeguard of the two ; a much more important protection has, however, been comparatively recently afforded to the Davy lamp by enclosing it in a case, which protects it to a great extent from the action of currents, but which, at the same time, even when constructed with glass on all sides, considerably diminishes the already very meagre light afforded by this lamp.

A lamp of Belgian origin, termed the Mueseler, and which has for many years past been officially adopted for use in the Belgian mines, presents important advantages over the lamps already referred to. These were recognised by the experimental committees of the leading Institutions of Mining Engineers before the appointment of the Royal Commission, and the lamp was then being introduced into some collieries, an action which has since then extended considerably. Some experiments and certain results of practical experience had, however, already tended to throw some doubt upon the wisdom of placing absolute reliance in the safety of this lamp, especially when the precise details of its construction, as worked out in Belgium, were more or less departed from by English makers. The results of the Commission's experiments confirmed the doubts which had been raised by experiments of the Midland Institute respecting the absolute safety of the Mueseler lamp, even when carefully constructed as regards the proportions of its component parts, and demonstrated that, under special circumstances, it might cause an explosion when exposed to a current of fire-damp mixture having a velocity of from six to ten feet per second. Under corresponding conditions, and even in currents of much higher velocities, the cased Davy lamp was found to be perfectly safe, and the establishment of this important fact has led to the adaptation of cases in various ways to the old types of safety lamps, many so-called new safety lamps consisting, in fact, of the Davy or Clanny protected, by enclosure in various ways, from the direct action of the current.

Protracted as have been the investigations which the Commissioners have carried out with safety lamps, their publication will, I

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venture to affirm, convince even those who, because they have not cared to inform themselves of the character and extent of work which was being done, have thought it right and just to publicly reproach the Commission with dilatoriness, that the curtailment of these researches would only have been detrimental to the conclusive, and therefore practically important, nature of the results arrived at. For these have not only led to decisive conclusions regarding the defects of the best known and most extensively used types of lamps, and the degree of safety and other merits of a large variety of modifications of them, as well as of new forms of lamps, but they will also enable the Commissioners to indicate with confidence several lamps which combine a great degree of safety with other important merits, and to specify a few among these which, while ranking highest in point of safety, and leaving very little to be desired in this respect, combine with this first essential the important adjuncts of simplicity of construction and fair illuminating power. It will, moreover, be possible to indicate some directions in which even these lamps are susceptible of improvement. It, therefore, only remains to be hoped that the results of the labour which the Commissioners have devoted to this branch of their inquiry will be accepted with the confidence they merit, and will be speedily utilised both by those who are responsible for the management of mines and by those who control the actions of the miner.

When the Commission's investigations of the relative merits of different lamps were already considerably advanced, Mr. Ellis Lever publicly offered a premium of £500 for a miners' safety lamp, either a perfectly self-contained electric lamp, or other lamp, which, while being of convenient size for carrying about, would continue to give a useful amount of light for not less than twelve hours, *and which would "not cause an explosion of gas under any circumstances at all likely to represent conditions which may occur in actual practice."* It was proposed that the judges to whom lamps submitted for competition were to be referred should include three scientists, nominated respectively by Mr. Lever, by the Royal Society, and by the Society of Arts. No less than 108 different lamps were sent in, and it need scarcely be said that the determination whether any among them fulfilled the prescribed conditions involved a very extensive series of experiments. The adjudicators appointed included two members of the Commission, who cheerfully consented to take upon themselves this very considerable addition to the voluntary labours already being carried on by them in the interests of the miners.

In arranging for and carrying out the tests of these lamps, the adjudicators had the great advantage of the experience gained by the Commission as to the nature of tests best adapted to elicit information regarding the good or bad features of a lamp, and as to the performances of the different types or modifications of lamps already known.

Only four electric lamps were submitted, and these altogether failed in fulfilling any one of the conditions laid down, excepting that of being self-contained lamps. As the tests of the various other lamps progressed in severity, the number of promising ones was rapidly reduced, and eventually not one lamp was found completely to fulfil the whole of the conditions under which the premium was offered, although there were several which ranked very high as regards safety and efficiency; foremost among these being the lamp of M. Marsaut (with three gauzes) and that of Mr. N. Morgan, of Pontypridd. To the constructors of these lamps gold medals have been awarded at the Inventions Exhibition, and it will be found that they rank among the lamps which the Commissioners are able to speak most highly of. But the premium which Mr. Lever placed at the disposal of the adjudicators reverted to him, and those who have great experience of the behaviour of safety lamps of the various well-known and recently developed types could scarcely have anticipated a different result, in face of the conditions laid down. Mr. Lever has since then again offered a similar premium, this time for "the invention or discovery of an economical, efficient, and safe substitute for gunpowder and other dangerous explosives used in the getting of coal." The Council of the Society of Arts could not see their way to attempt to comply with the suggestions of Mr. Lever that they should award this premium or appoint adjudicators for that purpose. Apart from the circumstance that there would be much less probability of the owner of the money being called upon to pay the premium, than in the case of the lamp competition, the Council could not have presumed even to suggest the great sacrifice of time in the performance of the very laborious and exhaustive experiments indispensable in this case, to such as would be really competent to perform the work of adjudication, which Mr. Lever appears to think at least as lightly of as of the offer of these prizes. It borders upon the amusing to observe in the article by the Manchester correspondent of *The Times*, to which such prominence was given on the 27th of last June, how the writer heralds offers of subscriptions and of premiums as illustrating the way in which his hero "gallantly attacks the problem (of accidents in mines) at all points," while he has no encouraging word for the men of science whose disinterested devotion to very arduous work, for which their sole probable recognition would be hostile criticism, or worse, can alone give any point to the "gallant attacks" of philanthropists like Mr. Ellis Lever.

The possibility of applying the electric light to the illumination of coal mine workings was one of the most prominent of the subjects which first suggested themselves to the Royal Commissioners as demanding careful study. The superficial observer, in noting the real progress made during the last few years in the facility and success with which the electric light has been utilised equally upon a large scale, for purposes of display or for the lighting up of large areas and buildings upon the comparatively small scale needed for illumination of small dwelling houses and offices, and upon the very minute scale, as in connection with surgical requirements, might have been pardonably led to the conclusion that there existed no very great difficulties in the way of at once presenting the miner with an electric light in almost as portable a form as a safety lamp, incomparably safer than the best of these, and capable of affording him a much superior light for the entire duration of his longest working hours underground. A little inquiry into the subject demonstrated to the Royal Commission that such a conclusion would be at least very premature, and that, although the subject was one most worthy of patient pursuit, the attainment of really useful results was beset with formidable difficulties. It is one thing to announce in oracular fashion, as *The Times* did, in a leading article last June, "that collieries ought to be lighted in a way to dispense with safety lamps," "that electricity is the one illuminating medium which can supply the light which miners want, without the flame which endangers them." It is quite another thing to apply the electric light with safety, even along main roadways, in mines in which fire-damp is prevalent. The writer of those lines would have been less confident in his assertions had he sought sufficient information to teach him that the fracture of a glow lamp, or the rupture of a conducting wire in a mine might be as much fraught with danger as the injury of a safety lamp or the lighting of a pipe. Had he, moreover, but learned by simple inquiry what progress had been made by patient workers at the time he was inspired thus to write towards setting aside those sources of danger, and providing the miner with a portable and efficient self-contained lamp, he would certainly have hesitated to assert that "no proper zeal has been brought to bear upon the conquest of difficulties in the application of electric lighting in mines, or to sneer at "the scientific brains, whom the public may encourage, though it cannot compel, to exert themselves as keenly for the illumination of a murky, dirty coal pit, as in the transformation of a plot of ground in South Kensington into fairyland."

The Royal Commissioners' report will deal with attempts which have been made in several of the mining districts to apply electricity to underground illumination; so far as distribution of the light in main roads is concerned, no great progress has been made, though there is now no reason why glow lamps, protected after the manner in use at our Government Gunpowder Works (as shown at the recent Exhibition), should not be distributed to considerable distances along such portions of a mine, the conducting wires being placed in secure positions and effectually protected. At Risca Colliery, in Monmouthshire, at Harris's Navigation Colliery, near Pontypridd, and at Earnock Colliery, at Hamilton, N.B., a commencement has already been made in this direction with satisfactory results. If, however, the miner is to have an electric lamp for lighting up drifts and working places, it must be supplied to him in a self-contained and really portable form, with absolute protection or isolation of the glow lamp from the surrounding atmosphere, and with a store of power sufficient to maintain an efficient light for ten or twelve hours.

The considerable improvements which have of late been made in secondary batteries, or accumulators, and the advance which has also been made in the construction of constant primary batteries, have led to very important progress towards the attainment of these essentials since lamps were submitted for competition for the Lever premium about two years ago. Mr. J. Wilson Swan, universally celebrated for his achievements in the matter of glow lamps, who was encouraged by the Commission in the early days of its existence to give his attention to the adaptation of the glow lamp to the miner's use, and has since patiently pursued the subject, has not long since succeeded in producing a lamp which, with its small storage battery, weighs little more than 8lb., and which will furnish a light equal to from two to four times that given by the better forms of safety lamp for a duration of ten or twelve hours. The beautiful miniature glow lamp which furnishes the light is perfectly shut out from the air and protected from accidental fracture, and the battery will bear swinging about without detriment. Mr. Swan is sanguine that he will ere long be able to effect an important reduction in the weight and bulk of the lamp, and he is not less hopeful of elaborating a primary battery similar in portability and light-giving power, the substitution of which, if successful, for the accumulator would have the advantage of dispensing with the necessity for providing

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dynamo-electric machines and power for charging the storage cells, though the great advantages presented by electric illumination, especially with arc lamps, of the surface establishments of a colliery, will probably lead ere long to the extensive employment of dynamo machines for such purposes. Other workers besides Mr. Swan, such as Mr. Coad and M. Trouvé, have been applying small primary batteries to the production of miners' lamps with some promise of success, although, as yet, the results furnished do not bear comparison with those obtained by Mr. Swan with the storage battery. Those who have spent any length of time under ground, especially in the very low workings which abound in coal mines, and at the high temperature which often prevails in the workings of deep mines, will have experienced the fact that any incumbrance may sometimes become very burdensome, and can well understand, therefore, that the weight and size of even the lightest form of battery with which an efficient light could be maintained for a sufficient length of time may prove grave obstacles to its extensive employment. Moreover, as the electric light can afford no indication of the condition of the atmosphere in a mine-working, its employment may not, even under the most favourable conditions, altogether allow of the safety lamp being dispensed with. But even if used only as an auxiliary means of illumination in working places, such lights as those which Swan and others will supply will prove very valuable. A similar lamp of somewhat larger size and comparatively much greater illuminating power may also prove invaluable for exploring purposes, especially after accidents due to outbursts of gas, when the best safety lamps may be of little use, even if they continue to burn. Such electric lamps must, indeed, become formidable competitors of the Fleuss lamp (included in the recent Exhibition), which has, in conjunction with the portable apparatus for the supply of respirable air to explorers, already performed important service in rendering access to mine workings possible where an ordinary lamp could not burn, and where the atmosphere was too foul to support life for any time.

THE INSTITUTION OF CIVIL ENGINEERS.

At the third ordinary meeting, held on Tuesday, the 24th of November, Sir Frederick J. Bramwell, F.R.S., president, in the chair, the first paper read was on "High Speed Motors," by Mr. John Imray, M.A., M. Inst. C.E.

The second paper read was on "Dynamo-Electric Machines and their Engines," by Mr. Gisbert Kapp, Assoc. M. Inst. C.E., of which the following is an abstract:—In this paper the author summarised the improvements which had been made within the last few years in the design and construction of dynamo-electric machines and engines used to drive them. Starting with the mechanically imperfect machine first introduced by Gramme, he showed how, by degrees, the nature of the strains occurring in those machines became better understood, and engineers began to employ adequate means to meet those strains. Also how, by a better arrangement and proportioning of the various parts, the efficiency and power of these machines had been increased, while at the same time their weight and price for a given power had been reduced. Those improvements had mainly been effected in the armatures and the field-magnets. The former consisted in holding the wires firmly in place, and in admitting air to all parts of the wires, and, in some cases, also to the core of the armature. Another improvement consisted in supporting the core by solid metal spokes or arms, instead of by the old-fashioned wooden hub. As regarded the field-magnets, the substitution of soft well-annealed wrought iron for cast iron had enabled the makers of dynamo machines to increase the electromotive force from 20 to 30 per cent., and also to obtain machines which were almost self-regulating. In consequence of the ventilation of the armatures, the density of current carried by the wires had been increased considerably, in some cases even up to 6,000 amperes per square inch, although the general practice was to employ only 2,500 amperes. The author next classified the dynamos, according to their armatures, into there great divisions; first, dynamos with armatures wound on the Hefner-Alteneck principle; second, those with cylindrical armatures, wound on the Gramme principle; and, third, those with disc armatures, wound on the Schuckert principle; and he gave a formula by which the electromotive force created in any of these armatures could be calculated from the constructive data of the machines. The question of the length of conductor required for every volt of electromotive force produced in the external circuit was next inquired into, and after certain assumptions, which were fairly in accordance with general practice, he found that the length of conductor required to produce one volt was as shown in next column.

Speaking of the intensity of the magnetic-field in a dynamo-machine, the author established the relation that the total number of lines of force passing across the armature could be represented as the ratio of the exciting power and magnetic resistance, the latter consisting of three parts; that properly due to the field-magnets, that due to the armature core, and that due to the air-space between the polar-surfaces and the surface of the armature core. The latter was assumed to be constant for all degrees of magnetisation, but the two former were supposed to increase in a certain way with the intensity of magnetisation; this increase, however, not being taken into account for low intensity. Formulas were then given for the magnetic resistance, from which it was found that the dynamo machines with single horse-shoe magnets required about 25 per cent. less wire than those with double horse-shoe magnets. With regard to the influence of the size of dynamos on the electrical energy which could be obtained from them, the author found that in small and medium-size machines the latter varied as the $3\frac{1}{2}$ power of their linear dimensions, and that the cost of manufacture varied as the $2\frac{1}{2}$ power, thus making the cost of the dynamo per lamp inversely as its linear dimensions.

	Inches.
1. Drum, long - - - - - - -	6 5
2. ,, short - - - - - - -	16·4
3. Cylinder, long - - - - - -	21·8
4. ,, short - - - - - -	26·1
5. Disc, square core - - - - -	26·3
6. ,, circular core - - - - -	26·3
7. ,, flat core - - - - -	78·8

The influence of the electromotive force on the cost of dynamos was shown by an example, which proved that, for economical reasons, it was better to work with average electromotive force, and that very high tension should only be employed if the expense for cables in the external circuits became very considerable. Detailed descriptions were given of nearly all the improved dynamo machines now manufactured in England, including the Edison-Hopkinson, Mather and Platt, Paterson and Cooper, Elwell-Parker, Crompton, Greenwood and Batley, the Brush Company, the Gülcher Company, and the author's dynamos. A table was also given which contained some of the more important constructive data of the various dynamos described, especially with regard to the density of current in armature and magnet wires, and the cooling surface provided to dissipate the heat which was necessarily generated by the current passing through those wires. As regarded the engines, the author maintained that the necessity of durability and economy in steam engines was as great if they were required to work dynamos, as in cases where they were used for driving mills, propelling vessels, or for any other purpose, and that, therefore, electricians should not be content with uneconomical engines, or with those which were liable to break down. If engine makers maintained that the speed at which dynamo machines must be driven was too great to allow them to make a substantial engine, electricians must reduce the speed of the dynamo to suit the engine.

The discussion upon these papers will be taken at the next meeting on 1st December.

LANT CARPENTER ON THE ELECTRIC TELEGRAPH.

At the Birkbeck Institution, on Wednesday evening, Mr. W. Lant Carpenter, B.Sc., lectured on the above subject, which he treated, not from a historical but from a practical point of view, dealing especially with the instruments and the principles on which they are constructed, methods for using land lines to their fullest capacity, and submarine telegraphy. The lecture was illustrated by diagrams, thrown by the oxy-hydrogen light, and also by actual demonstrations projected on to another screen, while Mr. Reece and Mr. Wilkinson, tutors at the School of Telegraphy, practically worked a line with a Post Office battery and the Wheatstone transmitter, in presence of the audience. In the course of his lecture Mr. Carpenter observed that in the United States of America dynamos were largely used for producing telegraph currents, but Mr. Preece informed him that he was successfully experimenting with secondary batteries for that purpose. Among the views on the screen was a photograph of a bill issued by the Great Western Railway Company on their first adopting the electric telegraph, inviting the public to come and witness the *modus operandi* of "the wonder of the age" at a shilling a head. The lecturer mentioned one instance, about four years ago, in which Mr. Preece, usually so punctual, had kept him waiting three-quarters of an hour, the cause being a magnetic disturbance which interrupted all the lines. Mr. Carpenter predicted an aurora borealis, which was seen the same night, and he then went on to the offices of the Eastern Telegraph Company, asking if their cables were working, because, if so, they would soon be interrupted, which they were afterwards, and there was no telegraphic news in the next morning's papers. While, with the Morse alphabet, a skilful operator could only send twenty-five words a minute, there were two methods of increasing the work of a wire, viz., multiplex telegraphy as practised in America, with its dryer climate, and the Wheatstone fast-speed trans-

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mitter, as used in England, by which one punched tape served for twenty or thirty different wires, and 200 words could be sent in a minute, as many as 230 having been transmitted between London and Edinburgh. He referred to the early difficulties connected with ocean telegraphy, and especially the incredulity of the public, who firmly believed that the first Atlantic messages were concocted in London. A view was shown of the artificial electric cable by means of which Mr. Varley succeeded in raising the capital for the first Atlantic cable. An admirable portrait was shown of the late Sir William Siemens, to whom for the cables, and to Sir William Thomson for the instruments, was attributed the chief credit for success in ocean telegraphy. Maps of the ground covered by the Eastern Company's cables were projected on to the screen; and it was stated that there were now 85,000 miles of ocean cables, which cost £30,000,000, while thirty vessels were engaged in laying and repairing, the last cable having been laid in twelve days without a hitch. After explaining the action of Sir W. Thomson's reflecting galvanometer and siphon recorder, and insisting on the importance of messages being written legibly ("Governor turns first sod," having been sent "Governor twins first son"), Mr. Carpenter gave a few statistics supplied to him by Mr. Preece as to sixpenny telegrams. Of the present mileage of 156,000 with 17,000 instruments, 26,000 miles and 900 instruments were due to the 6d. rate. The number of messages for week ended 14th inst. of the present year at the 6d. rate was 895,781 as compared with 638,657 for the corresponding week of last year at the 1s. rate. The number of messages in the last week of the 1s. rate was 670,116, and that of the first complete week of the 6d. rate, 846,745. While the average increase of inland messages has been 40 per cent., that in London was 60 per cent., the average price being 8d., as against 1s. 1d. under the old tariff, the number of registered addresses having increased from 2,000 to 9,000 in London alone. Mr. Carpenter, who had prefaced his lecture by thanking the Birkbeck Committee for their vote of condolence on the decease of Dr. Carpenter, concluded with the words of James Russell Lowell—that of all the benefits which science had conferred there was none greater than that by which a common nervous system transmits a common emotion.

GREENOCK PHILOSOPHICAL SOCIETY.

The third lecture of this session was delivered recently by Professor Jamieson, of the Glasgow College of Science and Arts, on "The Latest Developments of Electric Lighting for Houses, Ships, and Mines,"—Mr. Edward Blackmore, president of the society, in the chair. After reviewing the progress that had been made in electric lighting on the incandescent principle, and stating generally the number of private houses, as well as ships and mines that had been lighted within the last four years, Prof. Jamieson referred to the electric railways at Portrush in Ireland, Brighton, and Blackpool, as well as the system of telpherage at Viscount Hampden's, in Sussex, and drew an analogy between the flow of water in pipes and the electric current through wires, explaining the meaning of the various electrical terms used by electricians to denote pressure, resistance, current, and power, and showing how the terms understood by all in the one case helped to an understanding of the other. He then showed how it was that large currents of electricity could not be so economically produced from ordinary primary batteries (on account of the expense of the materials consumed) as could now be generated by a steam engine, gas engine, water wheel, or turbine driving a dynamo; and he illustrated the construction and principle of the dynamo by freehand sketches on the black board and several large wall diagrams. The construction of the incandescent lamp was similarly treated, as well as the accumulator or secondary battery. He reminded his audience of the box containing stored electrical energy which had been sent to Sir William Thomson about three years ago from Paris, and upon the report which Sir William had given of it, all of which, he said, had now been more than fulfilled, for the very storage batteries which he was using to light up the lecture-table and diagrams with had been in constant use for sixteen months, and, as far as could be ascertained, they were just as efficient now as when they first arrived in Glasgow. He next gave an example of how a private house might best be lighted, taking, as an example, Mr. Preece's house at Wimbledon. Further, he gave the results of a very careful estimate for a sugar house or factory, where upwards of 300 gas jets were now in use, proving that with that number of lights the electric light would be the cheaper of the two forms of lighting by about 9 per cent. per annum. Ship lighting was then discussed by the lecturer, and the great advantages it possessed over oil and candle lighting; for, as he said, it was cooler, more easily manipulated, more artistic; there was no smell and no products of combustion to tarnish gilt work or destroy drapery and books. He showed various designs for ship fittings, lighted by accumulators on the lecture platform, as well as some beautifully designed transparent vases and fittings to illustrate house decoration. Finally, he showed what was evidently of great interest to the audience, viz., an electric miner's safety lamp. This lamp and its electric charge, capable of keeping it alight for about ten hours at over one candle-power, was handed round, and its advantages pointed out. It could, he said, be taken down into a fiery or dangerous mine without fear of causing an explosion, as the glowing carbon filament was contained in a miniature Swan lamp.

THE ELECTRIC LIGHT.

Notification is given of an intended application to Parliament in the ensuing session for leave to bring in a Bill to extend the time limited by the Electric Lighting Act, 1882, or by the Saint James, Saint Martin, and Saint George, Hanover-square (West London), Electric Lighting Order, 1884, and the Electric Lighting Order Confirmation (No. 3) Act, 1884, or any one or more of them, within which any local authority might require the West London Electric Lighting Company (Limited) to sell their undertaking for such period, and, if need be, to alter the terms and conditions of such sale, in such manner as might be provided by the Bill. The Bill will contain clauses extending the time within which the local authority may, under the provisions of the order, serve a notice on the company requiring them to apply to the Board of Trade to direct that any part of the area included in Schedule B shall be added to the area included in Schedule A respectively annexed to the order, and also to extend the time within which the local authority, on the failure of the company to apply to the Board of Trade, may apply to the Board to remove such part or parts from the operations of the order. Further clauses will be contained in the Bill to extend the time within which the company are or might be required by the order to lay down distributing mains for the purposes of general supply, as defined in the order, and to exempt the company from any penalty thereto; providing that Section 27 of the Electric Lighting Act of 1882 shall not apply to the company or their undertaking, and prescribing "the terms and conditions on which any sale or purchase (if any) of the undertaking or any part or parts of the undertaking of the company as aforesaid, may be required to be made." Powers will also be asked as the acquisition of land.

Application will be made by the Chelsea Electricity Supply Company (Limited) to the Board of Trade on or before the 21st prox., under the provisions of the Electric Lighting Act, 1882, for a provisional order authorising the company to produce, store, and supply electricity within the parish of Chelsea. The Bill will contain clauses of the usual description, giving the company powers to construct the necessary works; to lay down wires and other apparatus, and to break up streets in the localities proposed to be supplied; to acquire land, to levy "rates, rents, and charges for the supply of electricity and the use of any machines, lamps, meters, fittings, or apparatus connected therewith;" and to make agreements with the local authorities. The notice further states:—"The streets and other places in, over, or along which it is proposed to take power to place any electric lines or other works are all the streets and other places within the said area of supply. And among such streets and places it is more particularly proposed to place electric lines and works in, over, and along the whole or portions of the following streets and places (but not to the exclusion of the other streets and places within the said area), that is to say:—Pavilion-road, Hans-place, York-street, Vincent-street, Pont-street, Grove-place, Walton-street, Walton-place, Lennox-gardens, Milner-street, Cadogan-square, Cadogan-terrace, Cadogan-street, Draycott-place, Draycott-street, Sloane-street, Cadogan-place, D'Oyley-street, Little Cadogan-place, Elizabeth-street, Ellis-street, Sloane-square, Lower George-street, Halkin-terrace, Westbourne-place."

LIGHTHOUSE ILLUMINANTS.—ELECTRIC LIGHT APPARATUS.

REPORT OF PROF. W. GRYLLS ADAMS, F.R.S., &c.

Description of Machines.

The machines now being tested at the South Foreland are three De Meritens alternate current magneto machines of the largest size made by him, having 60 permanent magnets, arranged in five rings of 12 magnets and 24 coils on each ring of the revolving armature. Each coil consists of four layers of wire, and is 27 millimetres deep, and about 100 millimetres wide. The 120 coils when arranged in parallel circuit for lighthouse work have a resistance of about one-twentieth of an ohm. The three machines are distinguished as L No. 1, L No. 2, and L No. 3, and their internal resistances are ·044 ohm, ·49 ohm, and ·056 ohm respectively.

The five rings of coils on each of the machines are connected in parallel circuit when all the brushes are down, but the collectors and brushes on each machine are made in three sections, so that it is possible to employ one ring only of magnets and coils, or two rings only, or the remaining three rings, or the whole five rings together, by bringing the respective brushes in contact with their own collectors, which are insulated from one another by ebonite rings or flanges on the ebonite axis which insulates the collectors from the axis of the machine. The diameter of the armature carrying the revolving coils is 2ft. 6in., or 760 millimetres, and the driving pulley is about 16in., or 400 millimetres, in diameter.

When revolving at the normal speed, 600 revolutions per minute, the magneto machines have been found to work with very great steadiness and with great efficiency. The electromotive force is about 75 volts and $\frac{2\pi\gamma}{T} = \cdot 3$ ohm nearly, where γ is the coefficient of self-induction and T the periodic time of the machine. When running with the circuit open, a very considerable amount of work is spent on the friction and internal work within the machine, but on closing the circuit this is greatly diminished, and the output of the machines, or the electrical energy in the external circuit, exceeds the *additional* work done to produce it. Thus, a single machine absorbs 4·2 horse-power when running at 600

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revolutions with the circuit open, yet only absorbs 10·4 horse-power with the circuit closed with one arc lamp in circuit, when it yields in electrical energy in one case 6,000 watts, or 8 horse-power, and and in another 6,600 watts, or 8·8 horse-power, in the external circuit. In the same way, two machines when clutched together and working in series, so as to work two arcs in series, absorb 9·35 horse-power when running at 600 revolutions with the circuit open, and yet were found to absorb only 20·51 horse-power with the circuit closed and two arcs in series, when they yielded in electrical energy 12,500 watts, or 16·8 horse-power, in the external circuit.

Thus, the external efficiency of these machines, when working separately or together in series, was found to be respectively about 81 or 82 per cent. The electrical energy per second is estimated by multiplying the average electromotive force by the average current as measured by an electro-dynamometer, by multiplying the average electromotive force, as given by Cardew's voltmeter, by the average current as given by Siemens' electro-dynamometer.

The electromotive force was also determined by a quadrant electrometer, by joining the needle to one pair of quadrants, when the expression for the electromotive force becomes $(V - V_1)^2 = E^2 = \frac{2d}{k}$, where d is the deflection, and k the constant of the electrometer.

The method of determining the work done in the arc by joining the pairs of quadrants of the electrometer to the two ends of a known resistance placed in the circuit, according to the formula

$$d_1 = k(V_1 - V_2)\left(V - \frac{V_1 + V^2}{2}\right) = kCr\left(V - \frac{V_1 + V_2}{2}\right),$$

was also tried, but the introduction of even a small resistance, r, materially altered the electromotive force and also the current in the circuit, and the method was not sufficiently sensitive. Thus, when the deflection by the first method, or $\frac{k}{2}(V - V_1)^2$, was 120 divisions of the scale for an electromotive force of 57 volts, the deflection by the second method was only about 30 divisions when r was about one-fifteenth of an ohm. The addition of this resistance considerably increased the electromotive force, and diminished the current in the circuit.

At the South Foreland the leads from the machines to the arc lamps in the experimental tower have a resistance of ·066 of an ohm, and when two machines were clutched together and working in series, so as to supply two arcs in series, the yield of electrical energy per second was about 10,200 watts in the external circuit; whereas, when working in parallel circuits through the same leads to one arc lamp, the yield was only about 8,600 watts in the external circuit.

A first series of experiments on the three magneto machines was made in July, 1884.

A second series was made in September, and further experiments on these machines and on the illuminating power of the light from the De Meritens arc lamps fed by them have been made during October, November, and December.

In each series of experiments the magneto machines have been found to work with very great steadiness and with very great efficiency.

When running with the circuit open a very considerable amount of work is spent on the friction and internal work within the machine, but on closing the circuit this is greatly diminished, and the output of the machines or the electrical energy in the external circuit exceeds the *additional* work done to produce it.

On July 11th, machine L No. 3, which supplies the light to the upper of the three lamps in the "A" tower, was first measured, the measurements being made in the engine room at the De Meritens distributor. The E.M.F., with circuit open, was 74 volts.

At first one ring of magnets only was employed to give the current to the arc, giving an E.M.F. of 32·6 volts, and a current of 37 amperes, or about 1,200 watts, *i.e.*, about 1·6 horse-power in electrical energy in the external circuit.

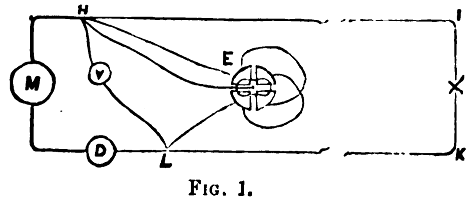

Fig. 1.

Two rings of magnets were now employed, when the E.M.F. became 37 volts, and the average current 65·8 amperes, giving 2,435 watts or 3·26 horse-power.

On employing the five rings of magnets, *i.e.*, the whole machine, and at the normal speed, the E.M.F. became 46·4 volts, and the average current 112·2 amperes, giving an average product E.C. or the average watts of 5,200 or about 7 horse-power the external circuit.

The leads from this machine were attached to a De Meritens arc lamp on the lowest stage in the "A" tower during the above experiments, and the resistance of the circuit was higher than the normal resistance.

On connecting the leads to the arc lamp on the uppermost of the three stages in the "A" tower, the E.M.F. at the terminals on the distributor was diminished to 34·5 volts and the current increased to 135 amperes, a change which was probably due to a diminution in the resistance of the circuit.

The instruments were arranged in the circuit as shown in the accompanying sketch (Fig. 1).

M is the magneto machine.
V the Cardew voltmeter.
D the Siemens electro-dynamometer.
E the quadrant electrometer.
X the electric arc.
HI and LK represent the leads to the "A" tower.
H and L are the binding screws on the De Meritens distributor.

In some experiments the voltmeter or the electrometer was removed from H and L to I and K, the extremities of the arc.

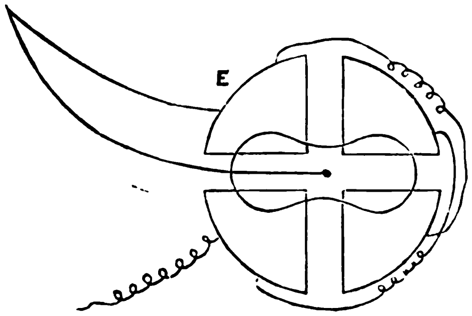

Fig. 2.—Picture of electrometer in the above diagram.

On July 12, machine L No. 1 was measured, and was found to give a current considerably lower than L No. 3 for the same electromotive force.

The current was only about four-fifths of the current given under the same circumstances by L No. 3, and the electrical energy or output of this machine was only about 4,150 watts, or about 5·6 horse-power.

The intensity of the light was estimated by Mr. Dixon in No. 1 hut on the evening of July 12, from 10:40 to 11:0 p.m.; during this period the average E.M.F. was 44·3 volts at the distributor, and the average current was 93·5 amperes, giving about 4,150 watts.

Later experiments showed that in consequence of the resistance of the leads to the tower about ·27 of the total electrical energy was lost by the way between the distributor and the "A" tower.

On July 14, machine L No. 2 was tested in the same way as the other two machines had been tested, and with the following results:—

With the circuit open the E.M.F. was 7·7 volts; on closing the circuit through the arc in the "A" tower, the following readings were taken:—

Revolutions.	Volts.	Amperes.	Watts = Volts + Amperes.	
600	43	123·3	5,302	——
	50	109·8	5,490	
600	47·5	117·0	5,558	
600	48	113·8	5,462	
600	48	115·8	5,558	
	48	113·4	5,443	
	47	118·1	5,551	
	48	114·2	5,481	
Mean 600 –	48	114·6	5,506	= 7·4 horse-power in the external circuit.

The work yielded is 1·2 horse-power greater than the difference between work consumed on closed and on open circuit.

From some cause (not apparent) machine L No. 1 gives less satisfactory results than the other two machines, and L No. 2 gives results slightly better than L No. 3.

L No. 1 gives 4,150 watts or 5·6 horse-power.
L No. 2 gives 5,506 watts or 7·4 horse-power.
L No. 3 gives 5,200 watts or 7·0 horse-power.

Machines L No. 1 and L No. 2 are capable of being mechanically clutched together, either to run in parallel circuit or to run together in series.

A series of preliminary experiments with the two machines in parallel circuit gave the results shown in Table A.

In this case there was one arc lamp and the leads to the "A" tower in circuit, and the high E.M.F. points to the fact that there is too much resistance in the circuit to give good results.

As regards efficiency, 9·35 horse-power is given by the indicator diagram as the work consumed, friction, &c., in driving the two machines with the circuit open; and 18·89 horse-power when the circuit was closed through one lamp; the work yielded being 2 horse-power greater than the difference between the work consumed with the circuit open and closed.

Another trial of L No. 2 in the evening of July 14th, when the Holmes machines were being driven from the same engines, gave slightly lower results, 47 volts, 113·2 amperes, giving 5,316 watts.

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TABLE A.

—	Volts.	Amperes.	Watts.	—
	53·5	155·3	8,308	
	54	156·7	8,463	
	54·5	158·1	8,618	
	56	156·7	8,776	
	56	156·7	8,776	
	55	155·3	8,541	
	56	155·3	8,696	
	55	155·86	8,572	
	55·5	155·3	8,618	
	55	155·3	8,541	
	55	155·3	8,541	
Mean -	55	156	8,580	= 11·5 horse-power in the external circuit.

The two machines L No. 1 and L No. 2, were also tried, being clutched together in series, with two arc lamps in series in the "A" tower, and gave the following results —

—	Volts.	Amperes.	Watts.	—
	79	128·5	10,150	
	79	129·2	10,210	
	78	131·6	10,270	
	76	133·0	10,110	
	78	131·2	10,230	
	77	132·9	10,230	
	78	130·2	10,150	
Mean -	78	131	10,193	= 13·7 horse-power.

The horse-power consumed on friction, &c., in open circuit = 9·35.

The horse-power consumed on driving the machines in series in closed circuit through two lamps = 20·51.

Thus the effective horse-power, or electrical work produced in the external circuit, is 2·2 horse-power greater than the difference between the work consumed with the circuit closed and with the circuit open.

The effective work done would probably have been greater but for the inferiority of machine L No. 1.

A second set of experiments with these magneto machines was made on the 18th, 19th, and 21st of July, when supplying the current to an arc lamp in the photometric gallery.

The Cardew voltmeter, the electro-dynamometer, and the quadrant electrometer were also placed in the photometric gallery, so as to measure the E.M.F. at the extremeties of the arc and the work done in the arc alone.

These experiments gave much better results than the previous ones, because the resistance of the leads to the photometric gallery is less than half the resistance of leads to the "A" tower.

As in the previous experiments, when the carbons in the arc were close together, the E.M.F. was low and the current high, the E.M.F. increasing and the current diminishing as the length of the arc increased, but so that the product or work done in the arc remained very nearly constant.

The E.M.F. from machine L No. 1 varied from 33 to 36 volts, and the current from 139 to 128 amperes, the average of work done in the arc being 4,608 watts, or about 6·2 horse-power.

The E.M.F. from machine L No. 2 being 72 volts with open circuit, varied from 34 to 37 volts with the circuit closed; and the current varied from 171·5 to 158·5 amperes, the average of work done in the arc being 6,084 watts, or 8·16 horse-power.

This machine was also employed in the experiments on Saturday, July 19th.

The E.M.F. from machine L No. 3 varied from 33·5 to 39 volts, and the current varied from 166 to 152 amperes, the average of work done in the arc being 5,666 watts, or 7·6 horse-power.

Thus all the machines give about 9 or 10 per cent. more work in the arc in the photometric gallery than they gave at the terminals of the machines when they supplied current to the arc in the "A" tower. This points to the fact that the leads to the "A" tower, and especially those from machine L No. 3 to the upper light in the "A" tower, consume too much work, or are too small.

In the experiments on Saturday, July 19th, with machine L No. 2, in the photometric gallery, the E.M.F. was 76·5 with open circuit, and the E.M.F. at the arc varied from 33·5 to 38 volts; the current varied from 171·5 to 161 amperes; the average of work done in the arc being 6,030 watts, or 8·1 horse-power.

On Monday, July 21, made experiments again with machine L No 2 (in the photometric gallery), when the E.M.F. varied from 35 to 37·5 volts, and the current from 167 to 163 amperes; the average of work done in watts, or the arc being 6,021 watts, or 8·07 horse-power.

On these two occasions the light given by the arc was measured by comparison with the Douglass 2-candle standard by the Bunsen photometer, placed in the photometric gallery at a distance of 341 feet from the arc. During these experiments the intensity of light in the arc varied from 11,000 to 15,000 candles, the greatest amount of light being given when the greatest current was passing, *i.e.*, when the arc is short.

On Monday, July 21, experiments were made with the two machines, L No. 1 and L No. 2, combined in parallel circuit with one arc in the photometric gallery.

The E.M.F. at the extremities of the arc remained very steady, varying only from 37 to 38 volts, and the current varied from 230·34 to 217·54 amperes, giving an amount of work done in the arc = 8,410 watts, or 11·3 horse-power. During these experiments the light given in the arc varied from 13,325 candles to 20,000 candles.

On employing L No. 3 machine again to give light to an arc in the "A" tower, we get an E.M.F. of from 43 to 48 volts, and a current of from 120 to 110 amperes, giving the electrical work at the terminals of the machine about 5,200 watts, or about 7 horse-power.

Being prevented from doing work with the De Meritens machines on the evening of Saturday, July 19th, I tested the Holmes machines by connecting to them the wires from the photometric gallery.

The Holmes machine, for the high light, gave an E.M.F. of 72 volts on open circuit, and an E.M.F. of from 25 to 31 volts with the circuit closed, giving a current of from 29·86 to 27·77 amperes. Thus the average of work done is 800 watts, or about 1 horse-power.

Two Holmes machines were then tried together, being locked together for quantity. Before contact the E.M.F. registered was 74 volts, with open circuit. The E.M.F. of the two machines was found to be 31 volts, and the current turned out by them amounted to 53·45 amperes. The average amount of work done in the external circuit was 1,657 watts, or about 2·2 horse-power.

The Holmes machine, for the low light, gave a current of about 32·5 amperes and 1,200 watts.

As an explanation of the inferiority of machine L No. 1 to the other machines, Mr. Sparling stated that when the machines were set up at the South Foreland, two of the magnets of this machine were set up in reverse position, and were afterwards set right, and possibly they had not fully recovered their magnetism.

It became a question whether, supposing two machines were worked together, the currents would tend to strengthen the weak magnets and improve the machine. It seemed advisable to run these machines together for some time with this object.

Some experiments were made on the running of two machines together, and the results obtained are of very great interest, since they prove for the first time experimentally what has been thought to be impossible, viz., that alternate current machines may practically be used as motors for the transmission of power.

To test whether alternate current machines would work in harmony without being rigidly made fast on the same axis, two machines which are usually clutched together were set running, being joined in parallel circuit, and when they had attained their usual speed of about 600 revolutions a minute they were unclutched, and each was driven only by its own belt. The two machines continued to run together very steadily, mutually governing one another; the electromotive force remained steady at 75 volts on open circuit, the same as the electromotive force of one of the machines which had been previously tested.

The machines were not quite equal in efficiency, for before this experiment one of the single machines had given a current of 135 amperes, and the other 165 amperes, with electromotive force of 37 volts, at the normal speed of 600 revolutions; now on closing the circuit from the two machines through the arc, the electromotive force became steady at 40 volts, and there was a current of 221 amperes, giving 8,800 watts in the external circuit, and the machines continued to run as steadily as if they had been clutched.

The lamp was now put out of the circuit and the machines short-circuited upon one another, without the slightest danger to the machines, owing to their high coefficient of self-induction. The belt was then thrown off one machine, when it continued to run at the same uniform speed, being driven as a motor by the electric current from the other single machine, and the electromotive force was equal to the electromotive force of the machine on open circuit.

An attempt was now made to introduce an arc into the circuit, but the motor immediately began to lose its speed and the arc became fitful with long beats, as in two musical instruments getting out of harmony, the beats increasing as the speed fell and the machine stopped.

A third machine similar to the others, but not placed on the same axis and having no mechanical connection with them, was also driven as a motor by one of the other two machines.

The experiments were resumed in September.

On September 19th, I took down to the South Foreland a box of resistance coils and other resistances, also a galvanometer, a Cardew voltmeter, a quadrant electrometer, and a Siemens electro dynamometer.

The internal resistance of the machines and the leads to the "A" tower and to the photometric gallery were determined.

Resistance of machine L No. 1 = ·044 ohm.
 „ „ „ 2 = ·049 „
 „ „ „ 3 = ·056 „

Resistance of leads from the distributor to the "A" tower = ·07 ohm (cold).

Resistance of wires to the photometric gallery = ·032 ohm (cold).

Four German silver wires, each having a resistance of 0·263 ohm were joined together in parallel circuit, making a resistance of 0·066 ohm nearly, *i.e.*, a resistance nearly equal to the resistance of the leads to the "A" tower, so as to determine the loss of power due to the leads.

We have seen that to the arc in the photometric gallery the machine L No. 2 gives an average current of 165 amperes, giving about 36 volts between the extremities of the arc, *i.e.*, giving about 5,940 watts in the arc = 8 horse-power in the arc.

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When this machine feeds an arc in the "A" tower the current falls to 114·6 amperes, and the E.M.F. at the terminals is 48 volts, and the watts in external circuit 55·06, or 7·4 horse-power.

When an additional resistance of ·066 ohm (cold) is introduced into the circuit, or ·067 ohm (hot), the current is still further reduced to 102·5 amperes, and E.M.F. between the terminals is 55 volts.

This shows the very great loss due to the resistance of the leads.

On the evening of September 24th, when this resistance was in circuit, the E.M.F. between the terminals of the machine was 55 volts.

The E.M.F. between the points P and L in the accompanying diagram of connections was 47·5 volts, and the E.M.F. between the points I and K, the extremities of the arc in the "A" tower, was 40 volts.

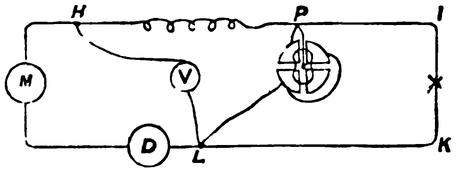

FIG. 3.

For some time previous to September 19 the biform electric light had been exhibited, worked from machines L No. 1 and L No. 2 coupled together in series, and measurements were made on these machines so coupled.

It was found that the E.M.F. at the terminals of the machines was 89 volts, the average current flowing was 143 amperes, giving 12,727 watts in the external circuit.

There was found to be a difference of 15½ volts between the two ends of the leads from the distributor to the "A" tower, so that about 2,180 watts or units of work per second were spent on the leads, leaving about 10,500 to be spent on the two arc lights.

These experiments were repeated on the evening of September 22, when the average E.M.F. was 92 volts, and the average current 132 amperes, giving 12,144 watts in the external circuit.

As these machines seemed to be giving better results than they did in July, machine L No. 1 was tried alone on September 23, when with an average E.M.F. of 43 volts between the terminals, giving an E.M.F. of about 37 volts between the extremities of the arc, the average current was 160 amperes, giving 6,880 watts in the external circuit, and 5,920 watts, or nearly 8 horse-power in the arc.

Thus, the running of the two machines together in series has greatly improved the weaker machine.

Machine L No. 1 is decidedly more efficient than it was in July, and is very nearly equal to machine L No. 2, and certainly more efficient than L No. 3.

——	E.M.F.	Amperes.	Watts (E.C.)	H.-P.
Machine L No. 1	43	160	6,880	9·2
" "	41	165·5	6,786	9·1
" " 2	41	164·4	6,740	9·0
" " 3	40	156	6,240	8·4

In all these cases the machines were supplying current to an arc in the photometric gallery.

Another experiment gave for—

——	E.M.F. at terminals.	E.M.F. at the arc.	Amperes.	Watts.	H.-P.
Machine L No. 2.........	38	32	176·2	6,896	9·2

On September 24, four German silver wires were combined to give a resistance of 0·657 ohm (cold).

The E.M.F. between the terminals was 57 volts (by Cardew), and the deflection of the electrometer 122.

The following simultaneous observations were taken :—

Volts by Cardew.	Electrometer.	Volts by Electrometer. $d=\frac{k.}{2}E^2$ $\therefore k=\frac{2d}{E^2}=\frac{480}{80^2}=\cdot075.$
80	240	80
57	122	57
55	114	} 55
55	113	}
53	105	53
37	50	36·5
32	39	32·25
40	60	40
35	47	35·4
41	62	40·7

This shows that ·075 is the true value of the constant for the electrometer, and that the readings of the two instruments are quite consistent and trustworthy.

The needle and one pair of quadrants of electrometer were now attached to the other end of resistance, when the readings were :—

Cardew.	Electrometer.	Volts by Electrometer.	Current.
52	76	45	—
55	90	49	100·1
55	85	47·6	102·46
53	78	45·6	107·2

giving a difference of potential of about 7 volts at the extremities of the resistance wires.

The resistance of these wires (cold) was 0·657 ohm, and the change of temperature, as roughly measured by bringing a thermometer in contact with German silver wire, was 90° C. Increase of resistance of German silver wire = ·04 p.c. for 1° C. ; hence the resistance = ·0681. Multiplying this by the mean current, 103·6 amperes, we get the product C.R. = 7·055 volts.

Now the resistance of the leads to the "A" tower is very nearly the same resistance as these wires, or ·077 ohm ; hence there must be a difference of potential of about 7 volts at the extremities of the leads to the "A" tower when a current of about 100 amperes is flowing through them.

The above comparison between the Cardew voltmeter and the quadrant electrometer shows that the Cardew instrument is a very satisfactory one for the determination of the electromotive force.

(To be continued.)

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. NOV. 25.		BUSINESS DONE WEEK ENDING NOV. 25. Highest.	Lowest.
Anglo-American	33,	34	35	32¾
Do. Preferred	55,	56	58½	55½
Do. Deferred	10,	11	12	9⅞
Brazilian Submarine	10¾,	11	11	10 11-16x d
Cuba	12,	12½	12⅝	—
Do. Preference	18½,	19½	—	—
Direct Spanish	1½,	2	2	—
Do. Preference	11½	12	—	—
Direct United States Cable	9¼,	9½	9⅜	9
Eastern Telegraph	11⅝,	11⅞	11⅞	11¾
Do. 6 per Cent. Preference	13½,	14	13 11-16	13 9-16
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅞,	13⅛	13⅛	12½
German Union	9½,	10	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7⅛	7
Do. Preference	13¼,	13½	13½	13 5-16
Great Northern	13⅞,	14⅛	14 1-16	—
Indo-European	32,	33	33	—
Reuter's	7,	7½	8	7½
Submarine	205,	215	208	—
West India and Panama	¾,	1	⅞	13-16
Do. 1st Preference	9,	9½	9½	9⅜
Western Brazilian	5⅝,	5⅞	5¾	5 9-16
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅞,	1	—	— x.d.
Oriental	3-16,	5-16	¼	—
United Telephone	12¼,	12¾	12½	12⅛ x.d.

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3,	3½	3⅞	3¼
Do. (fully paid)	4¾,	5¼	5⅜	4⅞
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1,	1¼	1¼	1 1-16
Maxim-Weston	½,	⅝	15-16	—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37½	36¾
India Rubber, Gutta Percha, and Telegraph Works	24,	25	25	24½

TRAFFIC RECEIPTS FOR OCTOBER, 1885.

COMPANIES.	Oct., 1885.	Oct., 1884.	Increase.	Decrease.
Cuba Submarine	2,100	2,230	—	130
Direct Spanish Telegraph	1,748	1,816	—	68
Eastern Telegraph	56,994	53,865	3,129	—
Eastern Extension	43,936	41,357	2,629	—
Great Northern	24,400	—	—	—
West Coast of America	3,475	—	—	—

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NOTES.

BURNT DOWN.—We are advised that the Simplex Electric Light Company's Works, Eccles Valley Mill, were burnt down at two a.m. on Wednesday last.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 27th November amounted to £3,050.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for November amounted to £56,245, and to £55,640 in the corresponding period of 1884.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of November were £2,021, against £1,729 in the corresponding period of last year.

THE ELECTRIC LIGHT IN BELGIUM.—We understand that the Courtrai Railway Station in Belgium is to receive an installation of the electric light. The firm of Bouckaert has been entrusted with the work.

THE TELEPHONE IN HONOLULU.—The Hawaian Bell Telephone Company at Honolulu have already a list of 400 subscribers. On other of the islands different companies are pushing their business rapidly.

THE PERSIAN GULF CABLE.—A telegram from Colonel Bateman-Champain announces the arrival of the ss. "Dacia" at Kurrachee, after the successful laying of the New Persian Gulf cable from Jask to Bushire.

THE TELEGRAPH BATTALION.—The "Poonah" is on her way from the Cape to Portsmouth, where she may be expected about the 9th instant, with the telegraph section of Royal Engineers, time-expired men, and invalids.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 30th November are £2,108, as compared with £2,344 in the corresponding period of 1884.

ELECTRIC LIGHTING OF TRAINS.—On the occasion of the visit of the King and Queen of Wurtemberg to Nice not long ago the Royal carriage was lighted by electricity. Their Majesties expressed satisfaction with the beautiful illuminant.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—This company give notice that their traffic reciepts for the month of November amounted to £40,427, and to £42,286 in the corresponding period of 1884.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 27th November were £2,385, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

A GOOD IDEA.—It is stated that M. Menier, the electrical engineer and contractor, has bought a large property in the Rue de Chateaud'un, Paris, which he is rebuilding. He proposes to sell the electric light at a reasonable rate to all the lodgers in the house.

PHOTOGRAPHY.—It is stated that the electric light is about to be introduced in the photographic studios of M. Langlois, Boulevard de Strasbourg, Paris. The installation will consist of three Gramme arc lamps, a Gramme dynamo, and a Popp compressed air motor.

ARTS AND INDUSTRY EXHIBITION AT MIDDLESBROUGH.—This Exhibition, which was opened on the 1st inst., has received an installation of the electric light, on the Brush system, put down by Mr. Goldston. The dynamo is driven from an 8 horse-power gas engine.

NEW TELEGRAPH STATIONS IN COREA.—The Great Northern Telegraph Company's telegraph system has been extended to Seoul, the capital of Corea, and to its port Ienchuan, Chemulpo, which two places are thus now in telegraphic communication with the rest of the world.

THE ELECTRIC LIGHT IN VIENNA.—At the half-yearly general meeting of the Imperial Continental Gas Association, held recently, the chairman, Sir Julian Goldsmid, Bart., stated that the association were making arrangements to light the Vienna Opera House with the electric light.

THE LIGHTING AT QUEEN'S GATE.—In the notice in our last issue of the small installation at 27, Queen's-gate, we mentioned that the designer of the chandeliers was unknown to us. We are now informed that they were manufactured and fitted up by Messrs. F. and C. Osler, of Oxford-street.

CATALOGUE.—Messrs. Woodhouse and Rawson send us a small pamphlet catalogue, containing interesting information about their make of incandescent lamps, besides the ordinary catalogue matter. In it they point out the direction in which they have been working in order to obtain practical and economical lamps.

ELECTRIC LIGHTING.—The Board of Trade has granted two licenses for electric lighting on a large scale. One of these licenses is granted to the Dalton-in-Furness (Lancashire) Local Board, for the district of Dalton-in-Furness; the other to Mr. John Edward Veale, for the district of the Austell Local Board (Cornwall).

LIGHTING THE SEWERS OF PARIS.—The question of lighting the sewers of Paris by means of electricity is under discussion. The project has been started by M. Guichard, a member of the Municipal Council. It is proposed to use Gramme regulators, supplied with current by the dynamo machines located in the Hôtel-de-Ville.

NAVIGATION OF THE SUEZ CANAL BY NIGHT.—Since the 1st instant, and until further notice, men-of-war and mail steamers furnished with the electric light have and will be allowed to proceed by night through that portion of the Canal comprised between Port Said and Kilometre 54, and *vice versâ*, subject to the regulations laid down by the company.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of November, 1885, was 2,707, estimated to produce £2,250, against 2,743 messages, producing £2,326, in the corresponding month of last year. The traffic receipts for the month of August, estimated at £2,200, realised £2,262.

OBITUARY.—The death is announced of Colonel Mangin, well known in connection with the electric projector which bears his name. Colonel Mangin was one of the few men who have laboured for science and for science alone.—We also regret to hear that Captain Trèves, whose recent researches have gained for him a well-deserved reputation in the electrical world, has also passed away.

LIGHTING OF A VILLAGE IN HOLLAND.—Messrs. Willem Smit and Co., of Slikkerveer, Holland, write to inform us that they have received an order to light up the village of Kinderdijk. The installation will comprise 400 sixteen candle-power Edison incandescent lamps and two self-regulating dynamos. The conductors, of about one mile in length, will be placed underground, and the existing lamp-posts utilised to carry the incandescents.

FIRE IN THE GENERAL POST OFFICE.—A few minutes before two o'clock on Wednesday morning some alarm was

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caused by the outbreak of a fire in the basement on the north side of the General Post Office buildings. The firemen stationed in the establishment having discovered the seat of the fire soon managed to overcome it. When the smoke had cleared away it was found that the fire had originated in a basket of tools, which were almost consumed.

PROF. HUXLEY.—Prof. Huxley writes to *The Times* to say that his long connection with the Normal School of Science and Royal School of Mines at South Kensington is not at an end. At the request of the Lords of the Committee of Council on Education, he retains the positions of Dean and honorary Professor of Biology in that institution. It is stated that a pension of £300 per annum has been offered to Prof. Huxley, in recognition of his eminent scientific services, and that he has accepted it.

FORGERY BY A TELEGRAPH CLERK.—On the 26th ult., Frank Arthur Whitley, telegraph clerk, of Cradley, was committed to the assizes for stealing postal orders, the property of the Postmaster-General, and also for forgery. The prisoner sold two postal orders to a tradesman, which were posted in the prisoner's presence to a London newspaper office. The letter did not reach its destination, and subsequently it was ascertained that one order had been cashed at Birmingham, and that the prisoner had forged the order.

TELEPHONIC PROFANITY.—By permission of the Archbishop the Compañia Colombiano de Telefonos have been allowed to pass their lines through the church steeples in Bagotà, U.S. of Columbia, for which they come in very handy owing to their construction. In one church eight wires pass through the steeple, and the curate of the said church has thought fit to cut the wires twice in succession, giving, as his reason for this step, that they profane the church, telephones being a work of the devil.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The annual general meeting of this society will be held at 25, Great George-street, S.W., on Thursday, December 10th, at 8:30 p.m., for the election of council and officers for the ensuing year. The following papers will also be read:—"A Method of Eliminating the Effects of Earth and Polarisation Currents in Fault Testing," by Walter J. Murphy, assistant electrician E. and S.A.T. Co.'s ss. "Great Northern;" "A Method of Localising a Fault in a Cable by Tests from One End Only," by H. Kingsford, associate.

AN INTERESTING PAPER.—At a recent meeting of the New York Electrical Society, President Van der Weyde read a paper on a method of obviating the inaccuracy connected with the use of the differential galvanometer. He employs a double switch, by means of which he shunts the divided currents alternately into the opposite coils of the galvanometers, and then takes the mean of the two readings. He applies the same principle to the Wheatstone bridge, by alternating in the same way the relative position of the two fixed arms of the bridge. This suggests itself to us as being very much like Mance's method for the elimination of polarisation currents.

ELECTRICITY AND SHIPS' COMPASSES.—In an article contributed to the current issue of the *Nautical Magazine*, Mr. Bottomley is of opinion that the following points should be attended to in all cases of lighting ships by electricity:—With continuous current machines two wires, well insulated, should always be employed; the insulation of the wires should be tested periodically; if any connection with the iron of the ship is found, the fault should at once be made right; when an alternate current machine is used a single wire may be employed and the iron of the ship used to complete the circuit without the current producing any effect upon the compass.

SPECIAL RATE FOR PRESS MESSAGES.—The Anglo-American Telegraph Company inform us that, dating from 2nd inst., a special rate of 10d. per word will be charged for press messages containing political and general news for publication, expressed in plain and unabbreviated language, between the United Kingdom and New York and Canada. Press messages to be forwarded when the lines are disengaged will be charged at the rate of 5d. per word. Arrangements for the application of these reduced rates must be made previously, either at the accountant's office, 26, Old Broad-street, London, or with the agents of the company in the provinces.

THE PAVILION MUSIC HALL.—The new London Pavilion Music Hall, in Tichborne-street, Piccadilly, which has been erected at a cost, it is stated, of between £30,000 and £40,000, was opened on Monday last. Provision has been made for lighting the hall either by gas or electricity, and on Monday night the electric light was introduced with great effect. The building has been erected from the designs of Mr. J. E. Saunders, architect, of Finsbury-circus. Messrs. Peto Brothers are the contractors. The gas fittings and the machinery for the electric light have been supplied by Mr. Cannon, gas engineer, of London-road, Lambeth.

SOUTH WALES INSTITUTE OF ENGINEERS.—At a meeting of this institute held at Cardiff on Thursday, 19th ult., a paper on "Recent Improvements on Electric Light Apparatus," by Mr. Sydney Walker, was taken as read. During the course of a discussion which followed Mr. Massey stated that whereas three Victoria dynamos tested last year at Buckingham Palace were found to take from 42 to 49 horse-power to do a certain amount of work, very careful tests made recently showed that exactly the same work could be done for an expenditure of 37 horse-power in one of the newer Victoria machines; that two Crompton dynamos required 31 and 32½ horse-power respectively, and that an improved Siemens dynamo gave precisely the same electrical output with only 28¼ horse-power.

LLOYD'S PROVISIONAL ORDERS.—Application is intended to be made by the corporation of Lloyd's in the ensuing session of Parliament for an Act to extend and enlarge their powers as regards the "collection, publication, and diffusion of intelligence," and to provide that the publication and diffusion of any such intelligence shall be deemed to be a privileged communication from them. By other clauses power will be sought for to authorise them to establish signal stations and to erect signal houses, with all requisite telegraph and telephone wires, appurtenances, &c., "at such places on the coast of Great Britain and Ireland and the islands appertaining or belonging thereto as they shall think fit, and to maintain and work the same," such powers, however, together with the taking of lands or houses for the purpose, to be exercised only with the approval of the Board of Trade.

THE ELECTRIC LIGHT AND THE ADMIRALTY.—The Admiralty have solicited the opinion of the dockyard officers at Portsmouth, as the result of the experience of the yard with respect to the best method of dealing with the internal electric lighting of Her Majesty's ships. They are desired to state in their report whether it is preferred to continue the present system of placing the work in the hands of contractors, or to arrange in future for the performance of all the electrical work in ships by the dockyard *employés*, making separate contracts for all the material that may be required, in which

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should be embodied the proper conditions for testing before receiving the several items. The officers are also required to state what number of workmen and leading men is considered to be a proper staff for the Portsmouth yard, and what number of assistant constructors for electrical fittings they think can be usefully employed at Portsmouth and at each of the other yards.

EARTHQUAKES.—It is reported from Victoria, Australia, that the earthquake shock felt at Albury was confined entirely to the north-eastern district of Victoria. It was felt at Bright, Omeo, Beechworth, and Tallangatta distinctly.—Several great earthquake waves from the Pacific were observed at San Francisco on Thursday between 1 and 8 p.m., at intervals of 35 minutes. Besides the earthquake shocks which occurred recently at Velez Malaga, on the coast of the province of Malaga, there appears also to be some seismic disturbance on the opposite African coast, giving rise to landslips of considerable magnitude. The bed of the sea at the points affected is also reported to have risen. It is stated that the shocks of earthquake h .ve been observed at the following places in Western Switzerland:—At Sion, Gryon, Ollon, Nov. 15, 2:15 a.m.; Chevroux, south east bank of Lake Neuchâtel, Nov. 18, 9:25 p.m.; and Gondo, south face of the Simplon, Nov. 20, 5:45 a.m.

MEMORIAL TO THE LATE SIR WILLIAM SIEMENS.—A window, erected in the nave on the north side of Westminster Abbey as a memorial to the late Sir William Siemens, was unveiled on 26th ult. Before the ceremony, a gathering of the friends of the late Sir William, and of members of several engineering societies, assembled in the Jerusalem Chamber, where addresses were delivered by the Dean and Sir Frederick Bramwell. A procession was then formed and entered the nave, where the ceremony of unveiling was performed. The window is designed to set forth the sanctity of labour, and at the base is inscribed, "In Memory of Charles William Siemens, Knt., D.C.L., LL.D., F.R.S., Civil Engineer. Born 4th April, 1823; died 19th November, 1883. Erected as a tribute of respect by his brother engineers." After the unveiling, prayer was offered by the Dean, and the proceedings closed with the playing by Dr. Bridge of "The Heavens are Telling," from Haydn's "Creation."

WEST AFRICAN CABLES.—It is announced that telegraphic communication has been completed between St. Thiago, Cape de Verd Islands, and various ports on the West African coast, thus connecting Europe with the Portuguese possessions, Bulama and Bissao, and the French settlement at Conakry, about eighty miles north of Sierra Leone. These stations, we are informed, will shortly be opened for traffic, the routes being *viâ* Cadiz or *viâ* Lisbon. The first of these will be through the Direct Spanish Telegraph Company's cable, the Spanish Government land lines, and the cables of the Spanish National Submarine Telegraph Company. The second is through the cables of the Eastern Telegraph Company and those of the Brazilian Submarine Telegraph Company. We strongly advise that the latter of these routes be chosen, for the reason that telegrams passing over the land lines of the Spanish Government invariably reach their destination in a mutilated condition. In connection with the West African cables, we may mention that Mr. March Webb returned from Praia, St. Thiago, on Wednesday last, having completed the staff arrangements and handed over the new lines of the company to Mr. Parsone, the resident manager.

THE WASHINGTON MONUMENT.—The improved arrangement for protecting the Washington Monument from lightning are now approaching completion. On the lower part of the aluminium pyramid which terminates the shaft has been fitted a collar, from which project eight 3in. metallic rods. To the corners of this collar four copper rods, about ½in. in diameter, are secured, extending down the edges of the pyramidal apex. These are joined together at a number of points along their length by horizontal strips of metal. All are securely joined to the corner or edge rods; and along both horizontal and edge rods metallic points will project at right angles to the rods, and at distances of 4ft. or 5ft. from each other. From the base of the small aluminium pyramid a thick copper rod extends to the capstone, and from the extremity of this rod four rods of copper, each having a diameter of ¾in., proceed downward, and are led to the four middle piers of the iron structure which carries the elevator and the stairway. At the bottom the earth connection is made by four heavy copper rods, which project several feet into a well of moist sand, at the bottom of which water is always standing.

THE TELEGRAPH IN CHINA.—According to *Nature* telegraphs in Southern China are extending with rapidity. Pekin in the far north is connected by a direct line through Canton with Lungchow on the frontier of Tonquin, the extension from Canton to the latter place being made during the recent war, purely for military purposes. Thus we have one great line stretching through the Chinese Empire from north to south, and at the present moment a line is being constructed along the southern borders of China. Starting from Nanking in Kwangsi, where it joins the Canton-Lungchow line, it will extend for nearly 600 miles to Mung-lih in South Yunnan. The work is being carried out by the Chinese themselves with the assistance of one European, and it is stated that during the recent war the Canton authorities equipped a complete field telegraph staff, the members of which were so thoroughly trained that they have been able to put up thirty-five miles of line in a single day for war purposes. Telegraphs have now secured a firm footing in China, and their extension over the the whole country is a matter of time only, aided perhaps by political events. In the great movement towards a centralised government now progressing in China the telegraph line will play a vital part, as it will utterly destroy the semi-independence of the provincial viceroys, hitherto secure in their remoteness from the seat of government.

THE TELEPHONE IN PARIS.—It is announced that telephonic communication between Paris and Rheims was opened to the public on Tuesday last. The distance is 172 kilometres, but the electric resistance to be overcome between the two points is estimated at 217 kilometres. The ordinary telegraphic wire is utilised for the purpose, but there is a special telephonic station in the Plain of St. Denis, at the Pont de Soissons. The tariff is one franc for five minutes' conversation. At the inaugural *séance* held on Monday night conversations were held with sundry public functionaries at Rheims, whose voices were heard with perfect distinctness. In a leading article upon this subject the *Standard* says: "Conversation has been held in America between two people separated from each other by over 410 miles. In Persia it has been effected between Tabreez and Tiflis, 390 miles apart; in India over a distance of nearly 500 miles; and in Australia words could be perfectly made out when transmitted along a wire 300 miles long. But in all of these instances the feat was accomplished either at night or under exceptional circumstances, and in every case the wires were underground. Had they been overground or submarine the result would have been different. Conversa-

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tions have been held between Dover and Calais, between Dartmouth and Guernsey, and between Holyhead and Dublin. But there is no case where any persons had spoken through more than 100 miles of submerged cable."

THE INDIAN TELEGRAPH SERVICE.—The officers of the Indian Telegraph Department whose grievances in respect to promotion, pensions, and general treatment we commented upon in our leading article of 9th October, have been energetically continuing their efforts both in India and in England to obtain a thorough investigation of the subject. A strong committee has been formed, and has already received such powerful support that the attempt to intimidate it from official headquarters will almost certainly fail. It seems that the Director-General of Telegraphs in India has refused to receive any appeal coming to him in the form of a joint memorial or combination, as contrary to the rules of the service. But the committee have issued an assurance to its supporters that it fully understands the orders of the Government on this point, and has no intention of disregarding them. These orders, however, do not extend to communications addressed to members of the English Houses of Parliament, and as the Indian Government official responsible for the Telegraphs of India will neither redress individual wrongs nor listen to any statement of them in bulk, the aggrieved officers have determined to approach the ears of Government officials at home. We cannot blame them for taking this course; for it is only in this country that an acknowledgment is likely to be extracted that a gross miscalculation was made some years ago as to the requirements of the Telegraph service of India. This acknowledgment once obtained, probably there will remain, even in India, no difficulty in obtaining a confession that some sweeping measures of redress to the victims of official error are urgently needed. We notice that the Committee has reprinted our article above referred to, but that exception is taken to some remarks in the third paragraph of it, which the Committee intends to reply to in detail.

THE LATE HENRY FAWCETT.—In the "Life of Henry Fawcett," by Leslie Stephen, recently published by Smith, Elder and Co., the following interesting account is given of the sad accident which deprived him of sight:—"On September 17, 1858, Fawcett went out shooting with his father upon Harnham Hill. Harnham Hill commands a view of the rich valley where the Avon glides between the great bluffs of the chalk downs and beneath the unrivalled spire of Salisbury. It is one of the loveliest views, as Fawcett used to say, in the south of England. He now saw it for the last time. The party was crossing a turnip field and put up some partridges, which flew across a fence into land where Mr. Fawcett had not the right of shooting. In order to prevent this from happening again, Fawcett advanced some thirty yards in front of his party. Shortly afterwards another covey rose and flew towards him. His father was suffering from incipient cataract of one eye. He therefore could not see his son distinctly, and had for the moment forgotten their relative change of position. He thus fired at a bird when it was nearly in a line with his son. The bird was hit by the greatest part of the charge, for it was 'completely shattered.' A few pellets, however, diverged and struck Henry Fawcett. Most of these entered his chest, but, passing through a thick coat, only inflicted a trivial wound. Two of them went higher. He was wearing tinted spectacles to protect his eyes from the glare of the sun. One shot passed through each glass of the spectacles, making in each a clean round hole. Their force was partly spent, and was further diminished by the resistance of the spectacles. They might otherwise have reached the brain and inflicted a fatal injury. As it was they passed right through the eyes, remaining permanently embedded behind them. Fawcett was instantaneously blinded for life."

THE LIGHTING OF THE CITY.—At a meeting of the City Commissioners of Sewers, held on Tuesday last, at the Guildhall, Mr. Altman, chairman of the Streets Committee, brought up a report on the question of electric lighting in the City. They stated that they had for some time past had before them the question as to the desirableness of the Commissioners undertaking the supply of electricity, and, although it appeared clear that under the existing enactments the Commissioners could not advantageously do so, except for public purposes, they were still considering whether it might not be advisable for the Commission to make an installation of electric lighting upon a small scale; but the question needed further examination before they could submit a scheme for approval. They had also had under consideration proposals of the Anglo-American Electric Light Corporation, who for some years past had been lighting the line of thoroughfare extending from King-street, Cheapside, to Blackfriars Bridge, for continuing such lighting and extending the area, it appearing that, if the lighting was to be longer maintained, the cables must be renewed and installed in a more permanent and trustworthy manner than at present, which the company were not prepared to undertake except under conditions protective of their interests. The latest proposal of the company they regarded with some favour, but there were various matters of detail requiring further consideration before they could submit it for the approval of the Court. In the meantime they placed before the Court various reports upon the subject of electric lighting which had recently been made to them by the engineer, and they recommended that the same should be printed and circulated for the information of the Commissioners.—Mr. Altman moved the adoption of the report, which was passed unanimously.

THE INSTALLATION ON THE SS. "INVICTA."—Much has been said and written of the difficulties attending ship lighting, but nowhere are those difficulties more prominently noticeable than on board Channel steamers, where the engines driving the dynamos are frequently started and stopped, bringing heavy strains to bear upon both machinery and lamps. The rough and choppy seaway also necessitates the use of an incandescent lamp holder that will neither tear away the loops nor easily break contact. The installation on the ss. "Invicta," belonging to the London, Chatham, and Dover Railway Company, was, our readers will remember, put down by Siemens Bros. It consists of two Siemens dynamos, coupled direct with two Brotherhood engines of 8 horse-power, nominal, two 500 candle-power arc lamps for lighting up the quays when entering or leaving port at night, and about 95 Edison-Swan 20 candle-power incandescent lamps distributed as follows:—In the state saloon there are seven lamps in ground glass globes and pretty fittings, and in the companionway a group of three; over the engine room there are seven in a cluster, and in the ladies' saloon ten lamps in pairs and three single ones. The deck cabin fittings are ingeniously arranged, a hole having been cut in the partition wall of each cabin and a lamp inserted in a suitable outer globe, so that one lamp lights two compartments. Ten lamps are so arranged. In the general saloon there are two clusters of four and three respectively, and three single lamps on each side; the dining room is fitted with two pairs, a cluster of three and one single lamp; and a total of twenty-five lights are arranged in the engine room. Others are variously placed about the decks. One set of machinery feeds 75 incandescents,

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and the other supplies current to one 500 candle-power arc and, if required, 25 incandescents. Except in the case of the arc, which has an independent metallic circuit, the steel frame of the ship is used as the return or earth, and, as need scarcely be mentioned, with good results. The installation is under the care of the chief engineer, Mr. Huddle.

RAILWAY CARRIAGE LIGHTING.—A correspondent to *The Times* of Thursday last makes the following remarks upon the important subject of railway carriage lighting:—"The article in *The Times* of the 19th ult. justly complains of the very indifferent way in which many railway carriages are lighted at the present time notwithstanding that an efficient electric light has now been in use for at least two years; but if the question is closely examined much of the surprise at the backwardness in applying this system to railway carriages will disappear. This particular system is now in regular use on two trains on the Brighton and one on the South-Eastern lines, a dynamo being worked in each case from the axle of the guard's van while the train is running, the electricity thus generated being stored in accumulators and used as required. Those who have had the management say this method of lighting is perfect, and after two years' trial not a hitch has occurred, nor has any reparing been needed, and these railway companies will, it is expected, extend the system, as it is both cheaper and more effective than any other. Methods of lighting by compressed gas, &c., are undoubtedly superior to oil, and when the use of electricity and gas is fairly introduced oil lighting must disappear. The advantages in favour of the electric light as compared with gas consist in the superior quality of the light and its being always ready for use when a train enters a tunnel in the day-time. The complaint at present is that the trains lit by electricity or gas must be 'block trains'—*i.e.*, must not be broken up, and other carriages not fitted for electricity or gas introduced between those so fitted. This may be a disadvantage at first, but when all the carriages belonging to a line are fitted for one or other of these systems this difficulty disappears. After a favourable report of the Board of Trade, and two years' successful working of electric light in railway carriages, the time has gone by for further delay or further trials, only it unfortunately happens that many railway companies have their own theory and system, and this is the chief cause of the delay in the general adoption of train-lighting by electricity."

THE ELECTRIC LIGHT IN GLASGOW.—Some months ago the directors of the Caledonian Railway Company, having decided to substitute electric for gas light in the company's Central Station, at Glasgow, requested Mr. S. Dunn, the company's telegraph engineer, to carry out the necessary arrangements. The installation comprises a 70 horse-power nominal horizontal steam engine, two No. 7 Brush dynamos with laminated armatures, and two small Gramme machines, all driven by composite (canvas-gutta-percha) belts, manufactured specially by Messrs. R. and J. Dick, of Glasgow. The Brush machines each feed 25 arc lamps of 2,000 candle-power, and the Grammes one each of 3,000 candle-power; 45 of the lamps fed by the Brush machines are suspended within the station, three are in the booking hall and two in the verandah. The two arcs of 3,000 candle-power light the shunting yard outside the station. The lamps within the station are hung on pendants, and are placed about 25 yards apart, and 15ft. in height, along the centre line of each platform. From the Brush machines the conductors are seven No. 15 S.W.G. strands of highest conductivity copper, insulated and braided, and these have been led round all the platforms, the object being to divide the lamps fed by each machine equally over the whole station. Should it, therefore, be necessary at any time to reduce the lighting of the station by stopping either of the machines, half the lamps, *i.e.*, every alternate one, will be kept going by the machine left in operation. The lamps are of 16-hour Brush pattern, with improved winding, polished brass cases, and are fitted with alabastrine globes, wire protected. The effect, when lighted on Monday, 23rd ult., was exceedingly pretty, great steadiness and brilliancy being obtained throughout the installation. A small horizontal engine of 12 horse-power nominal has also been provided to drive an Edison-Hopkinson dynamo, feeding 200 incandescent lamps, for the Station Hotel. Most of these lamps are fitted up in the lower portion of the hotel, and are therefore required during the daytime. The small engine runs the machine while lighting is not required in the station; but by a special clutch arrangement the driving is taken up by the large engine as soon as it is started for the lighting of the station. Both engines were built by Mr. John Bennie, of the Star Engine Works, Glasgow.

THE QUEENSLAND TELEGRAPH AND TELEPHONE SYSTEMS.—According to a report of the Post and Telegraph Department of Queensland for the year, 1884, which has recently been issued, the revenue derived during that year from the telegraphs was £77,118. 2s. 6d., as against £70,583. 14s. 3d. in the previous year; an increase of £6,534. 8s 3d. The usual return shows that on the 31st December, 1884, there were 1,511 persons of all classes employed by the Post and Telegraph Department. The number of telegraph messages in 1874 was 311,246 transmitted and 33,867 received, while in 1884 it was 1,006,184 transmitted and 110,298 received. The revenue from telegraph messages in 1874 was £21,396. In 1874 there were 4,891 miles of telegraph wire, and in 1884 11,299¾ miles. The report of the superintendent of electric telegraphs, Mr. A. F. Matveieff, concerning the telegraph branch for 1884, states that since the last report the extensions have been as follow:—Miles of line, 338½; miles of wire, 640¼. Besides some 600 miles of line which are in course of construction there are now 7,138¼ miles of line and 11,579 miles of wire open for public business in the colony. Cables have been laid between Lytton and the Pile Lighthouse, also across the Brisbane River near the lower magazine, connecting Lytton with Brisbane by a line along the north side of the river. A cable connecting Woody Island with Fraser's Island will probably be laid before long. No faults have shown themselves in any of the submarine lines since the last report. The duplex wires have worked throughout satisfactorily. Quadruplex instruments have been received, and after having been tested arrangements will be entered into for working the quadruplex system between Brisbane and Sydney. The four telephone exchanges at Brisbane, Maryborough, Rockhampton, and Townsville, respectively, have been working on the whole well. At Brisbane there are now 287 subscribers, Maryborough 57, Rockhampton 45, and Townsville 51. These numbers include Government offices, several of which are connected. Such offices pay no rent, nor do they in any way contribute to the expense of the Exchange. In Brisbane 42 such offices are connected, being about one seventh of the whole number of subscribers. At Maryborough there are 6, and at Townsville 3, free telephones connected with the Exchanges. A mile of aerial cable containing 25 wires has been procured, and will shortly be tried. If not liable to damage through the intense heat of the summer the number of wires in the streets can soon be considerably decreased, or, rather, the same number carried to their destinations in a much more compact manner.

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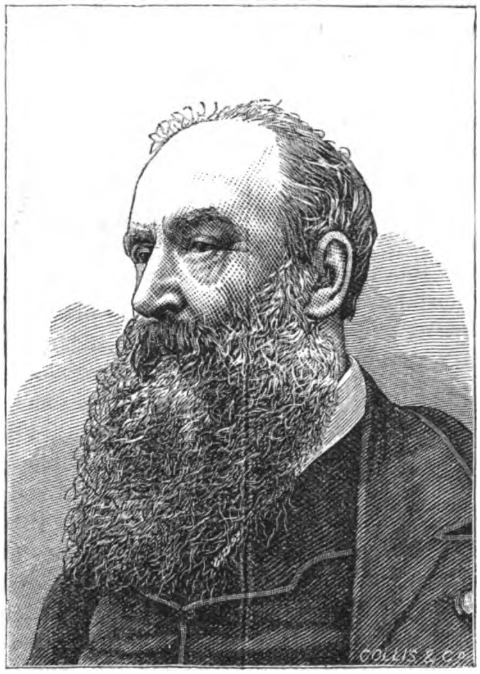
FREDERICK CHARLES WEBB.

WEBB, FREDERICK CHARLES: Born on the 1st of October, 1828, at No. 14, Surrey-square, Old Kent-road, London. He is the son of the late Mr. George Webb, formerly Secretary to the London Stock Exchange, who married Susanna, daughter of Thomas Bish. He received his early education at a private school at the Mansion House, Hammersmith, being afterwards placed at the Ecole Normale, at Brussels. Having learned French there he afterwards studied geometry, trigonometry, and navigation under M. Verhaart, Professor of Mathematics at the School of Navigation at Ostend; was placed for two years at the establishment of the Rev. Edward Jenkins (Chaplain to the King of the Belgians), at Brussels, where, amongst other subjects, he learned free-hand drawing and water colours, mechanical drawing, and fortifications. At the age of 15 he joined H.M.S. "Porcupine," a surveying ship, commanded by Capt. Frederick Bullock, R.N., but held no position in the navy (except for a short time when he was rated as a clerk's assistant), the object being to qualify him as a marine surveyor, so that on his obtaining a naval cadetship, which Capt. Bullock hoped to procure for him, he might at once receive the extra pay granted to the officers employed as surveyors. He was thus engaged for two years doing duty as a surveying officer, &c. During the two years he was in H.M.S. "Porcupine" the survey known as "The Downs," which includes the Goodwin Sands, was completed, and the free hand sketches of the leading marks, &c., were done entirely by Mr. Webb. He was also present at the erection of one of Captain Bullock's safety beacons on the Goodwin. The survey of the "Approaches to Harwich" was also completed whilst he was in the "Porcupine." Having waited and worked patiently for two years without pay, and not having sufficient interest to obtain a cadetship, he at last gave up the attempt, and the railway mania of 1845 breaking out he left the "Porcupine," and, under Mr. John Player, was engaged on the levels for the London, Newbury, and Bath Direct Railway. He was then placed with Mr. James Walker, of 23, Great George-street, engineer to the Admiralty, Trinity Board, Commercial Docks, &c., and was in that office grounded in all the duties of a civil engineer, such as drawing, tracing, taking out quantities, estimating, &c., and during the time he was with the firm the works in hand were the improvement of the Bedford Level drainage, the Admiralty Pier at Dover, the harbour of refuge at Alderney, St. Hilier's Harbour, improvement of Dover Harbour, improvement of Kurrachee Harbour, a new lantern to Eddystone Lighthouse, and other work. A particular manner of placing the supports of the roof, suggested by Mr. Webb, was approved, and adopted on the Eddystone, and in several other lighthouses. During the time he was with the firm he took the soundings for the contract drawings for the Admiralty Pier at Dover. He also made the whole of the surveys for the harbour of refuge at Alderney, and set out the two miles of railway from the quarries to the breakwater. After two years he parted from the firm, but was soon afterwards engaged for them in the surveys and levels of the Bedford Level drainage, on which work, as the gradient of the drains was to be only a fall of two inches to the mile, the levelling had to be very accurate. In 1850 he was introduced to Mr. Edwin Clark, then just appointed engineer to the Electric Telegraph Company. Mr. E. Clark engaged Mr. Webb as his assistant not only for the telegraph work, but as his own draughtsman for wrought iron bridges, and Mr. Webb drew out, under Mr. Clark's superintendence, the first iron bridge that Mr. Clark designed in London, and this was the first of the numerous bridges which that eminent engineer designed year after year. Mr. Webb soon, however, became engaged solely in the telegraph work, and executed the following:—The making of a complete set of surveys of the London street wires, of which no record had previously been kept; the erection of two wires between Brighton and Newhaven; six wires between London and Peterborough and two on to Grimsby; some 10 wires on the North London Railway; the surveys of the Lancaster and Carlisle, Maryport and Carlisle, and Stour Valley Railways. In 1853 the Electric Telegraph Company determined to lay cables to Holland, and Mr. Webb was appointed assistant engineer to the International Telegraph Company, the company formed to carry out this work.



Particulars of some of Mr. Webb's work whilst acting in the capacity of assistant engineer to the International Company have already appeared in our columns; but he also erected four wires between The Hague and Amsterdam, with underground wires in each of these towns. He acted as assistant to Mr. E. Clark in laying the cables across the Irish Channel, and laid them across the Firth of Forth, the Tay, the Solent, and the Humber, and for four years had the charge of the repair of all these cables. At one time, when it was considered dangerous to employ a steamer on the Dutch coast, as the ports were frozen, he repaired the cable in a Dutch fishing vessel, at a distance of thirteen miles from the coast. In 1857 he was engaged as one of the four engineers for the first attempt to lay an Atlantic cable; and he superintended the shipping of the "Agamemnon's" half at East Greenwich. The cable was, however, broken from the "Niagara," and Mr. Webb played only a negative part in that expedition; but he fitted up the "Leipsic" for picking up some of the lost cable.

In 1857 he helped Mr. R. S. Newall to complete the Bona and Cagliari cable, which had run short off Cape Spartivento, and to lay the cables between Cagliari, Malta, and Corfu.

In 1858 he and Professor Jenkin fitted up the "Elba," belonging to Messrs. Newall, Liddell, and Gordon, and, under Mr. Liddell, recovered some cables in the Mediterranean.

In 1859 he repaired the Dover and Calais cable, also the Cagliari and Malta cable, the fault in the latter being about half way between those two ports. In the same year he was engaged on the experiments made at Gloucester-road for the joint committee appointed by the Board of Trade and the Atlantic Telegraph Company, and during this time had the honour of showing to Faraday the "coil current," or, as it was for some time called, "Webb's current."

He also tested and reported on the 1858 Atlantic cable as regards the distance of the fault. His report showed how the resistance of the fault could be roughly ascertained by the *change in its resistance* caused by sending a negative current after sending a positive, a process which has since received

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the attention of many electricians. In the same year he was deputed by the directors of the Red Sea and India cable to test the sections between Aden and Kurrachee, and received on his return the thanks of the Board for "his full and interesting report."

In January, February, and March, 1861, he was engaged in the "Resolute" tug in trying to repair the Emden cable. It was a very severe winter, and the cable being deeply sanded up, Mr. Webb failed to repair it. The work was continued in April, May, and June under Mr. Frances's management, and finally repaired in June.

In this year he contracted with Messrs. Glass and Elliot to find the labour and his own services for laying the Isle of Man cable, the first cable having Latimer Clark's outer serving, and he carried out his contract.

Submarime telegraph work had been slack for several years, and Mr. Webb found occasional work in levelling for parliamentary surveys of railways. In December, 1862, he joined as chief the engineering staff of Messrs. Sir Charles Bright and Latimer Clark, who had just been appointed engineers to the Indian Government, under the late Lieut.-Colonel Patrick Stewart, for the making and laying of the Persian Gulf cable. In this capacity he had charge of the testing at Mr. Henley's works, and also fitted out the five sailing ships, and the repairing ship "Amberwitch"; acted as chief of the staff on laying three of the sections, and had entire charge of laying the fourth. He was then engaged by the Indian Government, on the recommendation of Colonel Stewart, to remain out for one year in "Engineering Charge of the Line," to teach the staff to repair the cable, to complete some of the work, and to design proper premises for the storage and repair of the recovered cable. These works were carried out by Captain Mereweather, R.E., and have given entire satisfaction. Mr. Webb came home from India in 1865, and tried in vain to obtain employment on the 1865 Atlantic Expedition. He consequently took again to levelling, and he executed work for Mr. John Fowler on several lines.

His friend, Mr. Zerah Colburn, started about this time the paper called *Engineering*, and Mr. Webb, who had previously contributed to the *Engineer*, was solicited by Mr. Colburn to write leaders for the new paper on electrical matters. He has been a contributor to that journal at various intervals ever since.

In 1867 he had charge, on the part of the contractors (the India Rubber, Gutta Percha, and Telegraph Works Company), of laying a cable from Havanna to Key West (Florida), and from Key West to a lonely place called Punta Rossa, 120 miles up the Gulf of Mexico. He ran a little out of course in laying the cable across the Gulf stream, and then the expedition was attacked by yellow fever, and fifteen out of sixty perished. On his return to England he found that a pamphlet to his detriment had been circulated by an eminent scientific man, and as the Board of Directors refused an inquiry, he had no option but to bring an action for libel against the author of the pamphlet, on which counsel agreed that an apology should be made provided each party paid his own costs; and an ample apology was accordingly tendered.

In 1868 he was engaged in fitting out the ships for the second Persian Gulf cable, recovering sixty miles thrown overboard from the "Calcutta," and taking all the rest of the cable out and re-shipping it, and received the thanks of his Excellency in Council the Governor of Bombay. An estrangement between the India Rubber Company and Mr. Webb lasted for a year, when Mr. Webb was again employed, and laid the present Post Office cable between Holyhead and Howth, when he received Lord Spencer, the Lord-Lieutenant, on board the "La Plata." He also for the same company acted as second to Sir S. Canning in laying the Marseilles and Algiers cable, and repaired it, and recovered the whole of the cable laid during the Franco-German war between Cherbourg and Dunkerque. He laid the Direct Spanish cable between Bilbao in Spain and the Lizard, and repaired it two successive years. He also laid the Marseilles and Barcelona cable, and diverted the Direct Spanish cable during the Carlist war from Bilbao to Santander, where he was introduced to Marshal Serrano. In 1874 he was engaged by Messrs. Siemens Brothers to command an expedition to complete the Platino-Brazilliera cable, and recover 170 miles of cable out of the wrecked steamer "Gomos," and was then made a Knight Officer of the Imperial Order of the Rose by H.I. Majesty the Emperor of Brazil, who he had the honour of entertaining on board the "Ambassador." This was the last work he executed, but he was lately consulted by the Indian Government on the third Persian Gulf cable. In 1877 he was appointed electrician to H.M.S. "Vernon," the torpedo school ship; but his health failed him, and he had to relinquish the appointment, which was never again filled up. He is probably the only member of the Institution of Civil Engineers who has been entitled to R.N. after his name.

Besides his articles in *The Engineer*, *Engineering*, *The Electrician* (old series), the *Telegraphic Journal*—which he edited for about six months—and our own columns, Mr. Webb is the author of a paper "On the Practical Operations Connected with Paying Out and Repairing Submarine Cables," which was read to a crowded audience at the Institution of Civil Engineers on the 23rd of February, 1858. On this occasion Mr. Webb had the honour of sitting at the council table between Faraday and Robert Stephenson. He is also the author of several articles in the *Philosophical Magazine*, and of a narrative entitled "Up the Tigris to Bagdad," a copy of which was graciously accepted and gracefully acknowledged by Her Majesty the Queen. Some of his articles in *The Electrician* (old series) were republished in book form, under the title of "A Treatise on Electrical Accumulation and Conduction." In these articles he showed that induction takes place in a circuit which he has termed "the induction circuit" He patented a means of preventing the teredo from attacking the gutta percha of submarine cables, and showed how the ordinary sextant may be made to take larger angles. Several of these instruments, which were certified at Kew Observatory as taking 163 degrees, were made, and one was taken by Captain Charles Bullock, R.N., on his survey in Japan, as Captain Bullock perceived and declared that the improvement was of immense importance. He was made an Associate of the Institution of Civil Engineers in 1857, and promoted to membership in 1868, and on November 26, 1884, was by the Council, in consideration of the services rendered by him to the Institution, and of his long connection with it, enrolled as a life subscriber.

THE STEAM ENGINE INDICATOR.—XI.*

BY AMICE.

We may now turn our attention to diagrams from high-pressure condensing engines working with moderate and high ratios of expansion. For this purpose we shall deal first with an engine working with a boiler pressure of 30lb., and a maximum cylinder pressure of 27lb., and with steam cut off at about one-tenth of the stroke, as shown by diagram (Fig. 38.) The engine made 58 revolutions per minute, and with a mean pressure of 13·81b. obtained from the diagram shown, and its fellow from the other end of the cylinder, indicated 463 horse-power. Fig. 38 gives a mean pressure, as will be seen from the figures upon it, of 13·27lb. By following this diagram it will be seen that the steam was admitted in such a way as to give full pressure in the cylinder instantaneously. It fell a little during the short period of admission, and at about one-tenth the stroke steam was fully cut off, and pressure fell to atmospheric pressure before four tenths of the stroke had been completed, and continued to fall until a little below 3lb. per square inch. This would not usually be considered quite a sufficient terminal pressure, as the back pressure or imperfect vacuum represents rather more than 2lb. Deducting this back pressure from the final pressure of 3lb. a pressure of but 1lb. is left to overcome the friction of the engine; not a sufficient quantity if the view that the terminal pressure must, to produce good results, be enough to overcome engine friction as well as back pressure. We are, however, inclined to think that this view is not altogether correct. The period during which the pressure is below that necessary to balance back pressure and engine

* For Art. 10, see *The Electrician*, 27th November, 1885.

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friction is very small, and it is not quite so certain that a loss accompanies expanding to pressures below that balance. It is difficult to see where the line could be drawn if terminal pressure is to be anything more than that necessary to balance back-pressure. We could not make it back pressure and friction, or we might next have to take in friction of belts and shafting. We should therefore, from our point of view, say that Fig. 38 is a good diagram representing good practice.

It is, we assume, unnecessary to give any further examples of diagrams, merely as pressure diagrams, of the use of the mean pressure obtained from them in calculating the indicated horse-power, so that we will in this case content ourselves with giving the diagram, with the pressures marked off. The diagram was taken with a spring which gave 16lb. to the inch, a scale which is suitable for the speed, but would not be stiff enough for higher speed.

It will be observed that this diagram (like Fig. 37, p. 47) is accompanied by a series of diagonal and horizontal lines. These we may at once say are lines which have been drawn as the means of obtaining graphically the theoretic expansion curve, and for obtaining the point of cut off when that is not known, or for assigning a point which shall give the point at which cut off would have to take place in order to produce the curve of the indicator diagram, supposing no steam to be undergoing expansion except that accounted for the stroke of the piston. There is, however, besides this an amount which is considerable admitted at every stroke to fill up clearance and port spaces, and this amount appears in the after part of the diagram, and gives a curve which appears to indicate a later cut off than is actually the case. This brings us to a consideration of the theoretical diagram of expansion.

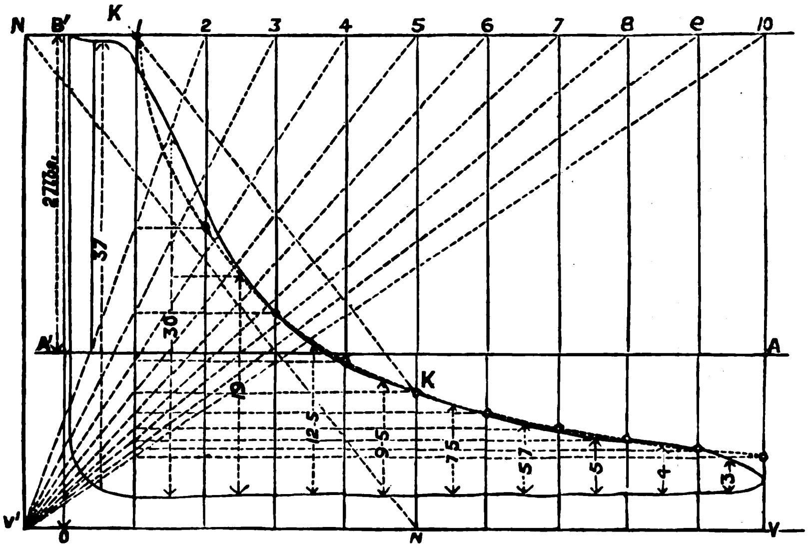

FIG. 38.

In engines of good design and in good order the steam pressure during expansion follows within narrow limits the curve drawn in accordance with Boyle's law, namely, that the pressure falls as the volume increases. The actual or indicator diagram curve falls more quickly at the commencement of the expansion than the law requires, but more slowly than it requires during the latter part of the expansion. This happens not to be so in Figs. 37 and 38 as regards the first part of the expansion, but it it is borne out by Fig. 37 as regards the latter part of the stroke, and will be shown more completely by diagrams to be given hereafter. Practically, the departure by a minus quantity at the beginning, and by an excess in the latter part of the expansion, makes the indicator diagram curve nearly identical in area with the theoretical or hyperbolic curve formed according to Boyle's law, and this is partly due to the steam admitted to fill clearance and port spaces, and partly to condensation in the beginning of the stroke. We shall therefore assume for purposes of calculation that the expansion of steam in a steam engine cylinder takes place according to this law, and that the curve representing the diminishing pressures due to increase of volume is a portion of a hyperbola. To the accidental reasons for the approach practically to the theoretic diagram, according to this law, although theoretically there are reasons why it should not, we shall refer hereafter, and will now proceed to the construction of the hyberbolic curve with a given base line. This we may do by calculation, or it may be done graphically, and as the former will afford some explanation of other matter as we proceed with it, we will take that first. Let

L = length of stroke in feet.

l = portion of the stroke during which steam is admitted, or the point of cut off, in feet.

s = any greater part of the stroke measured from the commencement in feet.

P = total initial pressure, *i e*, pressure in lbs. per square inch, including atmosphere.

P′ = total pressure in lbs. per square inch at end of a given part, s, of the stroke.

P″ = total final or terminal pressure in lbs.

L, l, and s may, of course, be taken in inches, but for convenience we will take them in feet, as given above.

Then the pressure at any given part of the stroke or

$$P' = \frac{P \times l}{s} \text{ or } P' = \frac{P'' \times L}{s}.$$

We have several times referred to the spaces not swept through by the piston, including the clearance between cylinder cover and piston and the steam ports. When dealing with a practical case the volume of this clearance must be reckoned in such terms as will enable it to be added to the period of admission of steam before cut off; for instance, if a cylinder be 100in. area, then each inch of the stroke of the piston will represent 100 cubic inches of steam, and cut off at one-fourth of the stroke, if the stroke be 20in., will represent 500 cubic inches, *i.e.*, with cut off at 5in. of the stroke. But, if the clearance between the end of the cylinder cover and the piston and the space in the ports, which it must be remembered has to be filled, be, say, 50 cubic inches, then the amount of steam admitted will be equal to the 500 cubic inches plus the 50 cubic inches, which makes the total quantity admitted equal to that which would enter during 5·5in. of the stroke, and this will of course affect the curve of expansion, although the 50 cubic inches of steam do no work during admission.

In the following example, however, we will assume that there is no clearance, and will return to an allowance for this hereafter.

In Fig. 39 let the base line $m\ n$ be the length of the stroke, say 6ft., $m\ c$ the initial pressure, say 63lb., $c\ d$ the period of

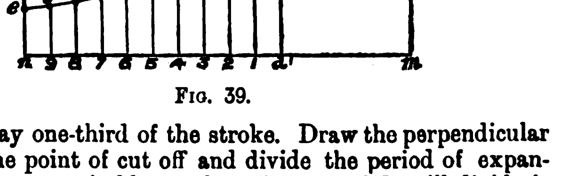

FIG. 39.

admission, say one-third of the stroke. Draw the perpendicular d, a' from the point of cut off and divide the period of expansion $d'\ n$ into any suitable number of parts. We will divide it into ten parts, as we have done in the case of the practical diagrams already given, and calculate by the first of the two of the above expressions the pressures at each of these divisions, 1, 2, 3, &c., and set them off by a scale of pressures on the vertical ordinates. The curve $d\ g$ traced through the ends of the ordinates is the hyperbolic curve of expansion. At the successive points of the base of the expansion line, each

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of the divisions being $\frac{4}{10}$ths of a foot, the expansion part of the stroke being 4ft., the pressures so found will be as follows :—

$$\text{At 1 it will be } \frac{P \times l}{s} = \frac{63 \times 2\text{ft.}}{2 \cdot 4\text{ft.}} = 52 \cdot 5\text{lb.}$$

$$\text{At 2 it will be } \frac{P \times l}{s} = \frac{63 \times 2\text{ft.}}{2 \cdot 8\text{ft.}} = 45 \cdot 0\text{lb.},$$

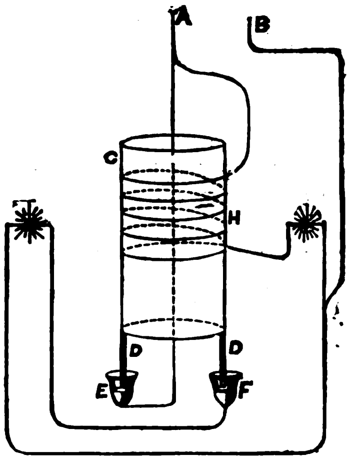
and so on for the whole of the ten pressure ordinates taken, or pressures at d',

	1,	2,	3,	4,	5,	6,	7,	8,	9,	n
are ...	63,	52·5,	45,	39·4,	35,	31·5,	28·6,	26·1,	24·2,	22·5, 21lb.

These pressures being set off on their respective lines, and a curve drawn through the points so marked off, we get the hyperbolic curve $d\,g$. Here we must leave the matter for another week.

AN AUTOMATIC COMMUTATOR.

M. Clerc, the designer of the Sun lamp, has quite recently designed a "shunt" for use in incandescent circuits where the lamps are in series. The coil H is wound round a cylinder of soft iron, C. The cylinder carries at its lower end the two contact pieces D D, which may or may not make contact in the mercury cups E F. The lamps as shown are in series. A and B show the line wires. When the right hand lamp is unbroken the current traverses the coil H, and through the lamp to B, while the action of the coil raises C and thus its



contacts, D D, out of the mercury. If, however, the lamp is broken, the circuit is completed through A E D, D left-hand lamp to B, and so the failure of the light is avoided.

THE ROYAL SOCIETY.

The anniversary meeting of the Royal Society was held at their rooms, Burlington House, on the 30th November. It will be unnecessary for us to dwell upon the admirable address of the President, which dealt most ably with the progress of science generally. Students of electricity will welcome the announcement that a Royal medal was awarded to Prof. D. E. Hughes, F.R.S., for his researches in electrical and magnetic phenomena. At the anniversary dinner the president, Prof. Stokes, mentioned the presentation of the Royal medal to Prof. Hughes, and proposed a toast to the recipient, to which Professor Hughes replied as follows :—

Mr. President, my Lords and Gentlemen : I cannot hope to find suitable words to express my thanks for the kind manner in which you have responded to the toast proposed by our president, Prof. Stokes, nor sufficiently thank him for the flattering terms in which he has mentioned my researches. The numerous experiments which led me to the invention of the microphone are based upon the discovery I made of the remarkable property of loose electrical contacts. If we make a bad joint or loose contact in an electric conductor, we find that not only do these disjointed conductors vibrate] in unison with the atmosphere, but in vibrating they produce an enormous variation in the strength of the electrical current. And if we join a telephone in circuit we find that every word spoken to the loose contact is repeated with absolute perfection. An equally remarkable fact is the reversibility of the effect, so that a loose electric contact will repeat in sound any variation of current passing through it ; consequently, we may speak to one loose contact and listen to a second, when every word spoken to the first will be clearly heard. The greatest power of sound, however, is obtained when used with a telephone, and the augmentation of sound is greatest when the original sound is most feeble. In order to study the effects of feeble sounds I at first listened to the ticking of a watch, and after making the microphone more sensitive, I was desirous of listening to sounds below the power of the human ear, such as those produced by the walking of a fly. This succeeded perfectly, but unfortunately flies were scarce at the time I was experimenting. I then studied sounds still more feeble, such as the sounds produced in a copper wire at each passage of an electric current—sounds which no human ear has heard direct, but which by the aid of the microphone are heard as a clear, ringing sound, due, I believe, to molecular motion in the wire itself. The microphone not only augments feeble sounds, but it will transmit the most complicated sounds of speech and music with absolute perfection. It has also been employed in physical, medical, and mechanical researches, and in France it has been of service to humanity in listening through the rocks to the sounds made by entombed miners, and by its indications encouraged the aid which finally saved them. The molecular sounds which the microphone revealed led me to invent an instrument which should penetrate inside of a metallic body, and reveal any change in its structure. This I accomplished in my induction balance. In this instrument induced currents from two separate coils are opposed and balanced with each other, but this balance of current is so sensitive that the slightest disturbance or reaction produced by the introduction of a piece of metal in one of the coils destroys the equilibrium. The amount of disturbance can be measured and the balance restored by the introduction into the second coil of a similar piece of metal, or by an equal reaction. If we could find two equal pieces of metal, such as coins, they would balance each other, but in practice the instrument is so sensitive that it points out differences in two similar coins fresh from the mint ; or in two pieces of equal weight cut off the same bar, due either to a slight chemical or molecular difference in the structure of the metal. Any physical or mechanical change, such as that produced by heat, magnetism, or strains, is at once declared ; and it is particularly sensitive to such changes in iron or steel. A curious example of its sensitiveness to iron occurred at the Paris Electrical Exhibition. Elisha Gray, the inventor of the harmonic telegraph, told me that fifteen years ago a small iron filing had penetrated his finger, giving at first some pain, but the filing and pain soon disappeared. He was anxious to know if the filing was still in his finger. I told him to place each finger successively in the induction balance, which he did, and all fingers gave perfect silence except one. This finger, however, immediately acted on the balance, producing loud sounds, and this finger proved to be the one which had been injured by the filing. So there could be no doubt that the filing still remained after a period of 15 years. If we place an iron bar or rod in the coils of the balance, we find that no two portions of the bar are exactly the same, and the slightest flaw, strain, or crystallisation of the iron is at once detected. Now, if we could apply this method to locomotive axles, we should be able to detect, in advance, any defect, and thus prevent the numerous accidents which occur on our railways from this cause. At present we cannot do this without first detaching the axle from the locomotive, but I hope some day of finding a modification of the balance which will overcome this difficulty. The electric sonometer aids the induction balance by comparing sounds from an absolute zero to any desirable extent, and it has been found most useful for measuring the power of hearing in those partially deaf. To cite a single example : Dr. Richardson, F.R.S., lately published an account of a youth who had been very deaf for many years. On being observed by the aid of the sonometer, the sonometer indicated that the cause of deafness was that of a solid obstruction, and upon operation a stone or pebble was found in the ear, which had been there unsuspected since childhood. On the removal of the pebble the hearing was immediately and permanently restored. I will not detain you by speaking of my researches in electricity and magnetism, nor of the many remarkable effects of the microphone and induction balance, but I am proud to say that all these instruments and researches were first presented to the world through the *Proceedings* of the Royal Society. I am deeply grateful to Dr. De la Rue for having on many occasions assisted me with his valuable advice, and allowing me to make use of his magnificent laboratory whenever the nature of my experiments needed such aid. Allow me to express my sincere thanks for the great honour conferred on me this day, and for the kind manner with which you have listened to my remarks.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XV.

Volume XV. of "The Electrician," price 10s. 6d., is now ready. Also cases for binding, price 2s.

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NATIONAL STANDARDIZING.

Following the example of some distinguished men of Science who have lately advocated its endowment by the State, certain lesser luminaries are preferring the claims of particular branches of science to this pecuniary honour. Prof. Ray Lankester thinks that a suitable laboratory for the study of bacteriology should be equipped at once; and as the progress of bacteria concerns the commonwealth at least as closely as the courses of the stars, the endowment of a bacterial observatory is as much the duty of the State as the maintenance of the establishment on Greenwich Hill. Similarly, Dr. Fleming argues before the Society of Telegraph-Engineers that a Standardizing Institution for testing electrical instruments should be nationally endowed, because the yard measure enjoys this distinction at the same spot. Prof. Lankester, who is not an astronomer, thinks, perhaps, that the stars we have always with us, but not the cholera; whilst Dr. Fleming, who is not a bacteriologist, regards exact electrical measurement as the foremost want of the age, not excepting the true theory of germs. It is charitable to suppose that both these specialists, and others we could name, are in reality merely on the look out for pickings. Contemporaneous with the threatened dispersion of old endowments there is an independent outcry for endowments new; and consequently everything that wants to be endowed just now had better be quick and say so.

This is all very natural, even for scientists, though their logical consistency in this relation may not be scientifically square. But, to say nothing of the General Election, there are prejudices against endowments deep rooted in the English mind not likely to be overcome in a hurry. Establishments, theological and corporative, which are cited as precedents, are really not State endowments at all; and the same observation will apply largely to institutions of an educational and scientific kind, the sole conspicuous exception being one not very encouraging as an example to follow. Dr. Fleming admitted that a demand for the endowment of research was suspected of being an experiment in the research for endowment. Certainly this is what it might lead to, for it has done so already. And the worst of it is you cannot blame anybody for the consequences which necessarily follow when once the path of independent research is departed from. Every individual concerned is at first genuinely and disinterestedly anxious to promote the branch of study to which he is devoting himself; and national endowment is the most attractive means of promoting it. But scientists are human beings, and we should have liked to hear what Dr. Fleming's answer is to the suspicion above referred to. Does he doubt that anything of the kind would happen, or that it matters nothing if it did?

Be this as it may, there is a practical difficulty in the way. The endowment is not likely to be got; and those who are best acquainted with the probabilities of the case stated at the meeting that the mixing up of the two questions—a standardizing institution, and a national endowment of it—would greatly hinder the realisation of either. In other words, the desired tests might be had at comparatively small cost, part of which could be borne by establishments already subsidised by the State for national purposes; but that the creation of a national institution for promoting quantitative electrical research would be a costly affair which the nation would refuse to put its hand to. And this seems to us extremely probable. Apart from the general objections to endowments, which unless universal must be by favour, there would be no limit to the demand and no intelligible reason for refusal. Even if the funds of a particular branch of the public service, such as the Patent Office fees, as suggested by Dr. Fleming, were available, every other conceivable interest that is represented on the Patent Office register would have an equally cogent claim to a share. And having disposed of all the money in that quarter, what is to be said to the claimants who render great service to the world without ever going to the Patent Office? Anyone can easily reckon up a score or more of such "institutions" that might reasonably ask for State assistance if it were granted to one. It is usual, therefore, except in some exceptional undertaking of obvious national importance, and when no other resources can be obtained, to reject all applications of the kind; and we think that this rule will not be departed from in order to establish a national Standardizing Institution for the benefit of electrical science or industry.

So obvious are these considerations that we cannot help thinking that the warm support Dr. Fleming received for his general propositions was on grounds quite different from those on which he himself had based them. The truth is, as everybody knows, the electrical standard itself is in need of being standarized—at least, so the high scientists declare, and probably will continue to declare while there is a fraction of a fraction to higgle about. Hence the desire for further research—not a remunerative business—and the perfection of electrical standards. But the practical electrician cares

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very little about these niceties, his chief concern being to be provided with some one place where his apparatus may be subjected to a test common to all. It matters not what the standard is so long as it is uniform, any more than it matters to the clothmaker what a yard is if only we are all agreed as to what its length shall be. Electrical measures have not yet attained any fixity, partly because experts are still disputing as to what it ought to be, partly because until now the practical necessity for decisive choice had not arisen. The dispute may go on indefinitely; but meanwhile the demand for a practical agreement has become urgent, and will not wait the establishment of an institution, national or private, for electrical research. Probably the Society of Telegraph-Engineers will for the present confine its action to the attainment of the less ambitious and more feasible of these two schemes.

CORRESPONDENCE.

DYNAMO MACHINES.—RATIO OF MAGNETISM TO MAGNETISING FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Several papers and notices have lately appeared which deal with the theory of dynamo machines. Two features appear to me to call for remark in these.

1. Fröhlich's formula is assumed to be a sufficient representation of the course of the ratio of magnetism to magnetising force.

2. It is assumed that it is possible to define the behaviour of a dynamo by means of considerations based only on the properties of the machine.

1. Now, Fröhlich's formula wholly fails to represent the truth for small magnetisms. In fact, the resistance to magnetisation has large values initially; it then diminishes as the magnetism increases, and ultimately increases again under the conditions known as "saturation."* Fröhlich's formula represents the saturation values fairly, but not the initial values. And it is clear that no theory of the starting of dynamos can be of any value which is not based on the correct representation of these initial values.

2. Wherever changes in the velocity of a dynamo are contemplated, as included in an investigation, it is clear that the governing function of the prime mover, or the relation between the velocity and the power afforded, is an essential element in the calculation. Thus, if an ordinary series machine be driven by an engine with a good governor at a uniform speed, the introduction of resistance into the circuit will rapidly bring the whole effect to nothing, whereas if the governor be removed, and the engine allowed to run at the higher speed natural under the diminished load, a compensation takes place, and an effect is maintained even against large resistances in circuit. Investigations in which no allusion to governing function is found cannot, therefore, give a complete account of the connection, for instance, between current and resistance in a dynamo machine.

I hope before long to apply the results of a series of experiments on the magnetic resistance of electro-magnets with pole pieces to the further elucidation of some of these questions, on the lines of my paper in *Phil. Mag.*, April, 1883, p. 275.—Yours, &c., R. H. M. BOSANQUET.

St. John's College, Oxford, December 1, 1885.

* Values for some bars may be seen in *Phil. Mag.*, 5th series, XVII., p. 532-4. In magnets with pole pieces the changes are of the same nature, but more prominent.

ELECTRIC HAULAGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Feeling particularly interested in the subject of electric haulage, and reading an account of a novel system in your valuable journal, I venture to ask you for a few particulars to supplement those already given. I cannot, for instance, reconcile your statement as to the consumption of electric energy with the results of experience. From numerous experiments, corroborated by the best authorities on tramway matters, I believe that the pull required by a vehicle on tram rails is from 25lb. to 35lb. per ton at a speed of six to eight miles per hour on the level road. You say that the engine of the Electric Locomotive and Power Company weighs 4 tons 17cwt.; the speed obtained is said to be eight miles an hour. Taking an average of 30lb. tractive force per ton at a speed of 704ft. per minute, I get 3·11 horse-power, without allowing for any friction in the gearing and motor; now, there is a level wheel running at 700 to 100 revolutions per minute on a circular rack; the motor, which probably weighs 5cwt., swinging round at 80 to 100 revolutions, must involve a large amount of friction, however nice the teeth of the wheel and rack may fit, the tendency being to lift the motor shaft with a leverage of 2ft., and jam the vertical pivot underneath the motor, which works the mitre gear on the driving axle. A rough calculation, which I have made from well-known data, shows that there is at least 1·3 horse-power lost in friction, even if all parts fit well and are thoroughly lubricated. This would bring the power to 4·4 horse-power for the locomotive alone, on the level road. On a rise of about 1 in 45, which occurs often, and which we call a moderate incline, your modern "Archimedes" will find that he will have to expend over 10 horse-power in his engine without attempting to haul the car, full of people. A full car will weigh another $4\frac{3}{4}$ tons, and thus double the power required once more. You state that the power of the motor is 4 horse-power, and that it consumes 40 amperes per hour, with an E.M.F. of 100 volts in the battery. I am not quite clear as to what is meant by "40 ampere hours," and I should think that, with a full car behind the engine of your modern "Archimedes" will not run faster than two or three miles per hour and use up current at the rate of 70 or 80 amperes on the level road, and I cannot imagine how he will get over an incline. I have always heard that electricity might be made to work tramway cars as cheaply as steam, because no separate locomotive engine is requisite; therefore, less weight and less propelling force, the adhesion on the rails being supplied by the car itself and the weight of the passengers, and it seems to me that the Electric Locomotive Company is taking a retrograde step. What, we may ask, is the cost of hauling cars as described by you, inclusive of depreciation?—Yours, &c., H. S.

November 30.

A PHENOMENON OF CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Reading a paragraph some days ago on Retardation in Mr. Sprague's *Electricity* (p. 80) I have derived a thought which leads me to believe that I have been reasoning in a diametrically wrong direction as regards what must take place in the induction coil. Assuming that the closed secondary circuit "relieved" the primary of a load as I suggested (p. 472, Vol. XV.), it would be relieving it only of *lateral* opposition, and not of any opposition in the path of conduction. This relieving process would be a kind of *yielding*, a yielding to electric force taking place not along the main path; it would, therefore, be a dissipation of the longitudinal tension. Such a yielding might be compared to the yielding of air in the air-chamber of a force-pump or in Dewar's spray-producer, in which examples the tension and discharge are moderated by the yielding, *while it lasts.* As regards the secondary wire influenced by induction, its yielding will, as I calculate, *more rapidly* terminate in equilibrium under each pulse of intermittent force when the terminals are joined than when they are insulated from each other. I regard the process of acquiring magnetism in the core as a similar lateral yielding. Until the electric force is balanced and checked in this direction, the action along the path of conduction must necessarily suffer. For my own part I find those considerations of *what work is being done*

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merely tend to confuse and lead me wrong; so that I prefer to go all the way back to Newton's third law. But, perhaps, this is only saying that men cannot read with one another's glasses.

I still expect to find from experiment that the pulses of the primary have more effect on a galvanometer when the secondary is closed, on the ground of more speedily obtained equilibrium.

Yours, &c., E. ALDRED WILLIAMS.

37, Burlington-road, W., Nov. 28th, 1885.

CANDLE-POWER OF ARCS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the report which you publish on lighthouse illuminants the candle-power appears to correspond fairly with a formula which I devised to fit the tests of the Franklin Institute, viz., $\frac{1}{300}$th of the square of the watts. For example, an arc of 6,021 watts gave 11,000 to 15,000 candles.

The comparison of measurements of arcs, especially small ones, with this formula, would be of considerable interest.

This would give only 410 candles for a 10-ampere 35-volt arc, which is probably rather below the mark.—Yours, &c.,

Halifax, December 1, 1885. ALEX. P. TROTTER.

THE SOCIETY OF TELEGRAPH-ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is neither my duty nor my desire to enter into the vexed question which forms the principal subject of your article upon the society in your issue of the 27th ult., beyond saying that I trust the course which the council have adopted this year will satisfy those whom you state are at present discontented. But there are minor points touched upon in your article in respect of which you have been led into statements which are not quite accurate, and which you will, I am sure, permit me to correct.

1st. You complain that if precedent be followed there will be no notification of the fact that the annual meeting is fixed for December 10th from the official source until "a few days prior to the event," and that as regards the persons to be elected, their names will be posted "on the day of the annual meeting, or possibly the day before." As a matter of fact, the date of the annual general meeting is made known to members on the sessional card sent to them the previous January, and a special reminder, accompanied by the list of members recommended for election on the council, is posted, not the day before, but eight days before the meeting.

2nd. You base your assumption that the general body of members are apathetic on the subject of the election upon the small number of balloting papers "deposited in the sacred urn" on the evening of the election; but I can assure you that the "innocent young men," and the "case-hardened old ones," to whom you allude form but a mere fraction of the whole body who exercise their right to vote upon the occasion, the "sacred urn" being usually nearly full of voting papers which have been previously sent in by post or by hand.—

Yours, &c., F. H. WEBB, Secretary.

London, Dec. 1st, 1885.

ELECTRIC MOTOR ON THE NEW YORK ELEVATED RAILROAD.

Preliminary trials of a Daft electric motor, the Ben Franklin, have been in progress for some time past on a portion of the Ninth Avenue Elevated Railroad of this city, extending from 14th to 52nd Streets. The dimensions of the principal parts of this motor are as follow:—Driving wheels, 48in. diameter; trail wheels, 36in. diameter; length over all, 14ft. 6in.; spread of wheels, 5ft. 6in.; diameter of armature, 25in.; weight of armature, complete with shaft, 850lb. Total weight of motor, 8¾ tons. Ratio of armature revolutions to drivers, 1 : 5·5. Ratio of peripheral speeds of armature and drivers, 1 : 2·8 +. The reversing arrangements consist of four brushes attached, with compound levers and so connected that the direction of rotation must necessarily be that best suited to the proper contact and wear of the brushes. There is also abundant provision made for varying the points of contact in proportion to the load, speed, &c. The regulating switch consists of a sliding plate having metallic contacts arranged on its surface in such a manner that a number of spring contacts effect changes in the internal resistance of the machine, so as to regulate the speed without the use of idle resistances, none of which are employed; the highest economy is therefore obtained with light as with heavy loads. The electric brakes are of the pendulum type, which were first used on the Mount M'Gregor motor in 1883, and are connected with a switch conveniently arranged to vary their power by variation of internal resistances. The mechanical brake consists of a compound lever attachment operated by a screw shaft through a thoggle mounted nut. Contact with the third rail, placed between the main rails, is effected by means of a phosphor-bronze wheel attached to a movable framework, which can be raised and lowered, as occasion requires, by means of the lever shown in the side elevation, Fig. 1.

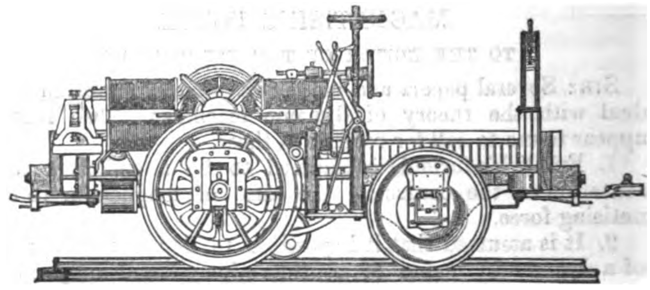

FIG. 1.—Side Elevation of the Electric Motor.

Upon each end of the armature shaft is a small wheel, formed with corrugations on its face which fit in corresponding corrugations on the face of a larger wheel mounted at each end of the driving-wheel axle. As will be seen by reference to the drawings, Figs. 1 and 2, the electro-dynamic machine is pivoted at one end in resilient bearings and attached to a vertical screw shaft at the other end, so as to enable the operator to vary the frictional contact between the friction gearing at will, and also affording an easy and convenient means for raising the whole machine to effect a change of armatures.

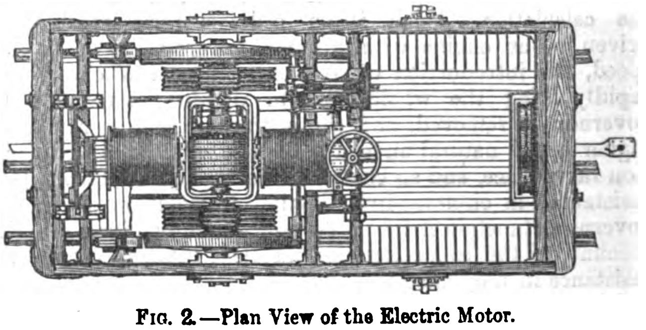

FIG. 2.—Plan View of the Electric Motor.

In order to avoid damage to the gearing and other parts of the electro-dynamic machine from shock, the whole machine is maintained in about equal resilience by means of alternating laminæ of iron and india rubber placed over the bearings of the drivers in lieu of the ordinary springs, and again in the pedestals at either end of the electro-dynamic machine. The object of using these laminated cushions is to avoid the too considerable motion which would result from the use of the ordinary springs, and at the same time provide a degree of resilience which enables the machine to run over very rough roads without the least derangement of parts.

The cab contains also a voltmeter, which shows the engineer the difference of potential on the track, just as the ordinary pressure gauge now indicates the pressure in a boiler.

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The rails are the ordinary 56lb. steel rail, insulated by means of the Daft insulator, which consists of an umbrella of cast iron, with head so formed as to readily admit of locking the base of the rail by means of two cap screws and washers. The standard is formed of any suitable insulating material; the standard now in use on the elevated road consists merely of baked hard wood saturated with asphaltum, which has so far been found to afford ample insulation for all practical purposes—the leakage with four miles of track now involved (two miles of double track), plus the switches, being inconsiderable. The joints are made by drilling holes in the web of the rails, and riveting strips of copper from one to the other; this method has been found entirely satisfactory both here and on the road now in operation in Baltimore—the resistance being thus reduced to nearly the calculated line resistance.

No difficulty has been experienced in making the switches, though in some instances a considerable interval has to be bridged by momentum alone, due to the necessity for leaving out the third rail in order to permit the passage of the ordinary steam locomotives; this difficulty would of course be removed in the event of the entire road being operated electrically. The maximum gradient is one of 105ft. per mile between 23rd and 34th Streets. This has been surmounted with ease with fairly well loaded trains, and on several occasions an average speed of 20 miles an hour has been attained.

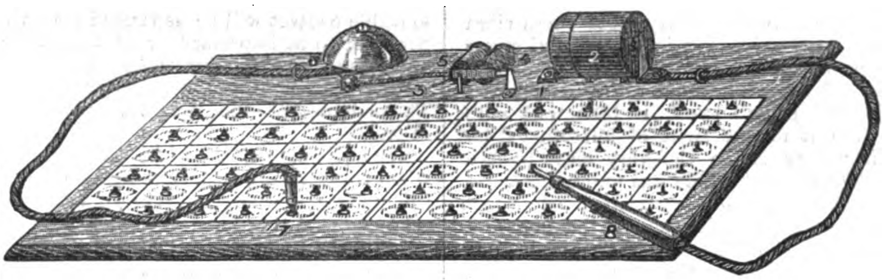
The track is vitalised by dynamos situated at the main station on 15th Street, about 200 yards from the track, it having been considered desirable to place the vitalising machines as near one end of the track as possible, so as to show the influence of distance in lowering the potential.

The effect of these two miles is, therefore, rendered equal to four miles where the station is centrally placed, and the loss of energy at the extreme end is barely observable. The vitalising system at the station consists of three No. 5 Daft dynamos, actuated by a Wright automatic cut-off steam engine, having a cylinder 18 × 42in., and a flywheel 16ft. by 26in. There is, in addition, a small arc-light Daft dynamo used for lighting the station and boiler room. The machines are connected with a switch-board, so that they can be placed in "parallel" or "series," as may be desired, and there is in addition an automatic cut-off, which operates in the event of a short circuit on the track, so as to open the circuit at a fixed point, and at the same time give the engineer notice by ringing an alarm. There is also an attachment to indicate when the short circuit is removed. The machines are connected to the track by means of 0000 copper wire, with Underwriter's line insulation suspended upon poles.

The motor has already run several hundred miles on the short track at 14th Street, making many hundred stops and starts, involving much severe work, hauling four cars for a considerable portion of the time, and also a two car train, for the purpose of making close observations as to the difference in consumption of fuel. With regard to this all-important question, the tests are as yet necessarily incomplete; but so far as they have gone, the indications are claimed to be eminently satisfactory. The extraordinary adhesive properties of a locomotive operated in this manner are evident. This feature is well illustrated on the line in Baltimore, which at one point has a curve of 75ft. radius on a gradient of 353ft., and yet no difficulty has been experienced by the motor in ascending this grade with a loaded train. So successful has been the working of the Baltimore road that two more motors have been ordered, making a total of four.—*Scientific American.*

A CHRISTMAS BOX.

The Electrical Apparatus Company has just introduced an electric toy which will be found very suitable for a Christmas



Box to children. Santa Claus is still expected to shower benefits on children at Christmas time.

The toy consists of electric bell circuits below a board. The circuits are left open and can be completed by the child. The contact pieces consist of a number of pins standing out of the board. In order to make the toy interesting a number of questions are printed on the left-hand half of a perforated cardboard, the answers being printed on the right-hand side. The cardboard is placed over the contact pieces, and a contact clip at the end of a flexible wire placed on the wire coming through the square in which the question is which requires an answer. A contact piece at the end of another flexible wire is brought consecutively into contact with the wires coming through the answer part of the card till the bell rings, when the child knows that the answer upon that square is the answer to the question asked. Full directions are issued with each "Automatic Instructor," which, so far as we have tested, acts admirably.

REIS'S ACOUSTICAL TELEPHONE. *(Concluded from page 54.)*

"Fig. 18 illustrates discord (*Dissonanz*). Why discords impress us unpleasantly I will leave my readers to judge at this time, though I may, perhaps, return to the subject subsequently in another paper.

"From the preceding it follows :—

"*First.*—Every tone and every combination of tones, on striking our ear, cause vibrations of the drum of the ear, the succession of which may be represented by a curve.

"*Second.*—The succession of these vibrations alone gives us a conception (*Sensation*) of the tone, and every alteration changes the conception (*Sensation*)."

The terms condensation and rarefaction as applied to sound-waves are entirely relative in their nature. A medium transmitting a sound-wave is rarefied when its density is decreased, and condensed when its density is increased beyond what it originally was, the extent or ratio of the condensations or rarefactions representing the amplitude of the sound-waves. Practically, then, the amplitude represents the amount of energy charged on the medium in order to mould it into waves. In the case of interfering waves, the amount and distribution of the energy in the resulting wave depends on the amount and distribution in the component waves. When the direction in which the energy acts is the same in, say, two waves, the amplitude of the resultant wave is the sum of the amplitudes of the two. If the direction is opposite, the amplitude of the resultant wave is the difference of the two. Two waves may completely obliterate each other, provided they simultaneously affect the same particles of the medium in opposite directions, with equal intensities, and for equal lengths of time; or, as it may be otherwise expressed, if the waves meet in opposite phases, are of equal amplitudes, and are of the same wave lengths.

Considering now the curve shown in the upper part of Fig. 17, as resulting from the simultaneous action of the notes *c*, *e'*, *g*, and

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c', it will be noticed that the condensation rises while the four notes are simultaneously condensing the air, but begins to fall when part of them are endeavouring to rarefy it as is indicated ; for example, between the third and the sixth abscissa, where a gradual fall is shown, while between the sixth and seventh abscissa, and for some distance beyond, the fall is more sudden. Now, although in a general sense, it is correct to regard the curve between the first and the 7½th abscissa as indicating a condensation of the medium propagating the wave, yet it is equally correct to regard all that part of the curve between the third and 7½th abscissa as representing a rarefaction of the medium, superposed on the condensation, since a decrease of the condensation at any time is practically a rarefaction. Moreover, its effect is practically the same as that of a rarefaction, since if the condensation moves the medium in one direction the rarefaction moves it in the opposite direction.

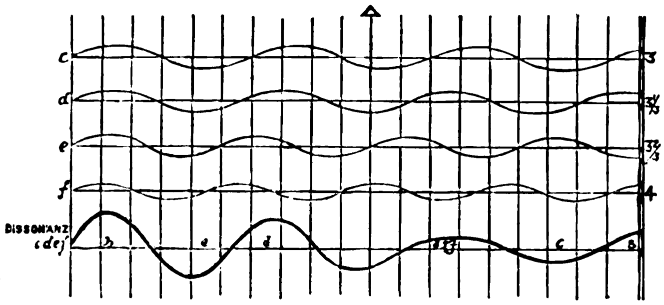

FIG. 18.

Studying Reis's curves in this light, is it not clear that he never could have intended to use the words "make" and "break" in the sense ascribed to him, but that when he spoke of the interruption occurring at every condensation and rarefaction he uses these terms in the sense above indicated? Does not the elastically-supported contact, with its adjusting screw, show that he did not intend the contact to leave the diaphragm completely, but that he wished it to follow its finer motions? Does he not say in the *Jahresbericht* article, "but the quality of the note depends upon the number of variations of amplitude (*Anschwellungen*) occurring in the same time?" "Now, my apparatus gives the number of the vibrations, but with far less strength than the original ones; though also, as I have cause to think, always proportional to one another up to a certain degree. But because the vibrations are throughout smaller, the difference between large and small vibrations is much more difficult to recognise than in the original waves, and the wave is therefore more or less indefinite."

If his apparatus, as he left it, with the elastically-supported contact and its adjustable spring, will speak in 1885, with absolutely nothing added to it, is it in the light of 1876 that it has been made to work? Is it not rather in the very clear light of 1860 and 1861, when the *Jahresbericht* article was published?

There are two other points in the *Jahresbericht* article which throw some light on the meaning which should be given to Reis's use of the words "make" and "break." The first of these is to be found in his description of the action of the core of the magnetising spiral. "The intensity also of this tone is proportional to that of the original one; for, in proportion as this is more intense, the motions of the membrane are greater, the motions of the hammer, also, and finally the time during which the circuit remains opened is greater, and, consequently, up to a certain limit, the motions of the atoms in the reproducing wire are greater, we perceiving them as greater vibrations in just the same way as we would have perceived the original sound-wave." If the "opening" of the circuit here referred to means, as we have suggested, its gradual increase in resistance, while the diaphragm was under the influence of the rarefaction, or while it was moving in a certain direction, then we can understand how the instrument could reproduce variations in the intensity of the transmitted sounds ; but, if it mean a complete break, then, since it is difficult to understand how the circuit, if completely broken, can be anything more than broken, it is equally difficult to see how the duration of the complete break could effect the intensity.

Again, Reis's claims as to the capabilities of his instruments "now in reference to the capabilities of the telephone," . . . "experiments showed that the sounding wire was capable of reproducing complete chords of three tones of the piano;" that is to say, it was capable of transmitting quality which would be clearly impossible if the instrument acted on the "make" and "break" principle in the sense claimed by the advocates of Bell.

If the paragraphs in Reis's article, in which he refers to the "making" and "breaking" of the circuit stood by themselves, then it might be admissible to put the construction on them before referred to; but, taken in connection with the other declarations and explanations of Reis, we do not see that such interpretation stands at all.

If, however, such interpretation be sustained, then it simply amounts to this—viz., that Reis did not understand the theoretical operation of his instrument. But we fail to see how this can injure his position as an inventor. If he produced an instrument whose mechanical structure was such as would permit it to reproduce articulate speech, and properly instructed others how to make and use it, then he is the true inventor of the same, no matter how erroneous his ideas may have been as to its theoretical operation. If, as is undoubtedly the case, scientific opinion of the present day is still uncertain as to what is the exact theory of the action of the articulating telephone, then Reis may justly be excused if he erred in his description of the same. Should Bell's theory of the undulatory character of the transmitted current, in the sense in which he claims it, be fallacious, as is by no means improbable, then are his claims to the modified forms of apparatus that he has produced to be regarded as untenable?

In the Legat description of Reis's apparatus already referred to we note the following in speaking of the movable contact :— "It is advisable to make the arm *c*, *e*, longer than the arm *e*, *d*, in order that the least motion at *c*, may operate with the greatest effect. It is also desirable that the lever itself may be made as light as possible, *that it may follow the movements of the diaphragm* (our italics). Any inaccuracy in the operation of the lever *c*, *d*, in this respect will produce false tones at the receiving station." The necessity for the contact to follow the motions of the diaphragm is precisely what we have insisted on. Legat, for some reason or other, does not appear to have obtained any valuable results with the instruments with which he experimented.

It would appear to be an assumption, bordering on impertinence, to deny to the man whose genius created the most marvellous instrument of modern science, a knowledge of the simplest principles underlying the operation of the instrument he has constructed. It is incredible that he, who modelled his transmitting instrument after the human ear, who explained so thoroughly by curves the peculiarities of the motion of its tympanum, and who wrote, "the function of the organs of hearing, therefore, is to impart faithfully to the auditory nerve every condensation and rarefaction occuring in the surrounding medium ; the function of the auditory nerve is to bring to our consciousness the vibrations of matter resulting at the given time, both according to their number and magnitude," could have so blundered, as to desire to obtain results that he especially designed the mechanical structure of his apparatus to avoid.

Any form of variable contact transmitter will cease to properly operate if spoken to in too loud a tone, since in such a case the movable contact will be separated from the diaphragm too long to permit it to be impressed by all its motions. By the use, however, of the regulating screw the pressure of the elastically-supported contact may be varied, so as to permit a fair use with a loud tone. This is true with the Reis transmitters, and equally true of the others.

We again assert, therefore, that the Reis transmitters operate, when transmitting articulate speech, in precisely the same way as the modern receivers, and presumably in the very way that Reis intended that they should operate, but that, however this may be, even admitting that he so strangely erred in his explanation of the way in which he conceived it to operate, then, nevertheless, if his description of the mechanical structure of his apparatus, and of the manner in which it was intended to be used, is such as to enable a skilled mechanic, with no other knowledge of the art than that imparted to him by Reis's publications and drawings, to make and use the same, then Reis is the first true and only inventor, and to him must be awarded priority of invention over all others.

Since the object of the contact pieces is to vary the electrical resistance of the circuit in which they are placed, by altering the extent of surfaces in contact, they must, of course, have been formed of some electrical conducting substance. Since, if such substance were liable to oxidation, it might, apart from the motions of the diaphragm, thus introduce a varying resistance into the circuit, the substance must not be readily oxidised. Reis employed for his contact pieces metallic platinum. Berliner, Blake, and, indeed, nearly all later inventors have replaced the platinum by hard carbon, since Hughes pointed out its superiority. This material, though perhaps better in degree, does not differ in the manner of its operation, as is indeed shown by the fact that the Berliner or the Blake transmitters will operate satisfactorily when their carbon contacts are replaced by metallic platinum, or that, conversely, the Reis transmitter will operate if furnished with carbon contacts.

In the early history of the Reis-Bell controversy, it was denied by the advocates of Bell that it was possible to make the Reis apparatus talk. When, however, it was proved by the most unquestioned testimony, and by actual demonstrations, that the Reis apparatus could and would talk, instead of fairly according to him the merit of the discovery, they adopted the specious plea that even if the apparatus would talk, it was only in the light of the experience of Bell that it could be made to do so ; that is, that the success of actual use of the Reis apparatus was by the use of the

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knowledge gained since 1876. Such reasoning would appear too illogical to need refutation. Let us, however, present the same reasoning in another light.

An apparatus, designed by Reis, to transmit articulate speech, made, we will say, in 1861, is left unnoticed in that strange way in which the world has too often failed to accept the gifts of genius, if born out of time. It slumbers amid the dust of age and neglect, while its inventor, unable to convince the world of its great value, at last dies disappointed and heart broken. Temporarily forgotten, it is re-invented by another and accepted by the world as the greatest discovery of modern time, and no honours are deemed too great for its supposed inventor. Again brought to light, the original apparatus is compared with the later alleged invention and found to resemble it in a remarkable manner. Doing absolutely nothing but to remove the accumulated dust of many years, it is placed in circuit with another receiver, or, indeed, even with its own receiver, and lo! it talks. Surprised at this success, the experimenter searches for Reis's description of such apparatus, and finds that he and others claim to have talked through such apparatus long ago. What, then, should be his indignant surprise, as one possessing that true scientific instinct of desiring to know the truth for the truth's sake, to be told that Reis must have falsified his record when he stated that such an apparatus would talk; that had it not been for Bell, the Reis apparatus would never have spoken? If it be a telephone in 1885, why was it not equally a telephone in 1861, especially when it was designed to talk, and when, if the most solemn statements are to be believed, it did talk? It is not, perhaps, saying too much to add that a defence of such a character is open to grave suspicions of insincerity.

And yet, what is the position in which the advocates of Bell insist on placing him, in order to enable them to continue to maintain his patent rights in the United States? Do they not assume for him a declaration that might not unfairly be worded as follows:—"I have made a grand and great discovery of so novel a character that I demand, for its protection, the broadest and most general patent that can be issued. I have discovered that if I use the regulating screw placed by Reis in an apparatus improperly called by him a telephone, and obtain a certain pressure of an elastically-supported contact against a diaphragm, that the apparatus will do what Reis and others claim that it did many years ago, but which I do not believe they ever accomplished. My discovery, therefore, is of so novel a character that I claim in general the use of electricity in the transmission of articulate speech, and consider it a sufficient proof of the infringement of my patent rights if any one hereafter succeeds in actually transmitting speech electrically."

Is Mr. Bell willing to permit others to continue to make such claims for him? We can hardly believe that his known sense of fairness will permit him to continue to do so. The credit that is legitimately due him, and which all are willing to acknowledge, should suffice, without his permitting others to endeavour to appropriate for him that due to Reis.

It has been said, "a century of Reis would not produce a speaking telephone," because Reis did not give the correct explanation of the manner of operation of his instrument. We beg leave to differ entirely from this statement. The apparatus of Reis, so far as its mechanical structure and the way in which it was designed to be used are concrrned, are entirely independent of any theoretical explanations of how such apparatus operated to produce the results for which they were designed. According to such reasoning, a century of Franklin would never produce a lightning rod, since Franklin, although he gave a full and correct description of the construction of his lightning rod, and explained how it was to be placed on the building it was designed to protect, alleged that the manner in which it operated was by drawing a hypothetical electrical fluid from the surcharged cloud and quietly conveying it to the ground. At the present, we do not believe in the fluid theory of electricity; therefore, there never was a lightning rod, and no such instrument can act as a lightning rod until we know the exact manner in which it lowers the higher potential of the cloud to that of the earth. Is not such reasoning nonsensical, and could it not be enlarged indefinitely?

It is an interesting fact that Bell approached the invention of his form of articulating telephone from very nearly the same standpoint as Reis; that is, from a study of the curves resulting from the combination of different tones, with, however, this difference. Reis designed his curves to represent the variations in the amplitude of the sound-waves, or the variations in the movements of the diaphragm of the receiving instrument. Bell, on the contrary, employed his curves to represent electrical undulations. Quoting from the specification of his U. S. Patent, No. 174,465, of March 7, 1876:—

"Electrical undulations, induced by the vibration of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the inducing body itself, and the effect of its vibration upon the air; for, as above stated, the rate of oscillation in the electrical current corresponds to the rate of vibration of the inducing body; that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration—that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body—that is, to the condensations and rarefactions of air produced by the vibration. Hence, the sinusoidal curve, A or B, Fig. 4 (our Fig. 18), represents, graphically, the electrical undulation, induced in a circuit by the vibration of a body capable of inductive action."

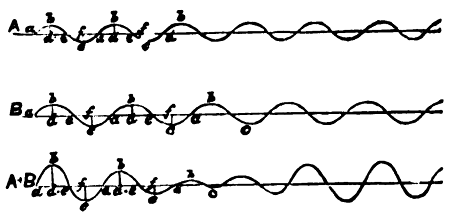

Fig. 18.—Curves Representing Electrical Undulations from Fig. 4, of Bell's U. S. Patent, No. 174,465.

The horizontal line, *a*, *d*, *e*, *f*, &c., represents the zero of current. The elevation, *b*, *b*, *b*, &c., indicates impulses of positive electricity. The depression, *c*, *c*, *c*, &c., show impulses of negative electricity. The vertical distance, *b d*, or *c f*, of any portion of the curve from the zero line expresses the intensity of the positive or negative impulse at the part observed, and the horizontal distance *a a* indicates the duration of the electrical oscillation. The vibrations represented by the sinusoidal curves B and A, Fig. 4, are in the ratio aforesaid of 4 to 5—that is, four oscillations of B, are made in the same time as five oscillations of A.

"The combined effect of A and B, when inducted simultaneously on the same circuit, is expressed by the curves A+B, Fig. 4, which is the algebraical sum of the sinusoidal curves of A and B. This curve, A+B, also indicates the actual motion of the air when the musical notes considered are sounded simultaneously. Thus, where electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced analogous to that occasioned in the air by the vibration of the inducing bodies."

The difference between Reis and Bell, then, is as follows:—Reis insisted on the necessity of reproducing in the diaphragm of the receiving instrument similar movements to those in the transmitting diaphragm, and endeavoured to obtain this result by an elastically-supported regulable spring, through the action of what he called makes and breaks. Bell also insisted on the reproduction in the receiving diaphragm of the motion of the transmitting diaphragm, but declared that in order to achieve this result exactly similar undulations must be given to the electrical current that traverses the wire between the two stations. Reis, it will be observed, designed his curves to represent electrically the magnetisation of the receiving electro-magnet, which, as Legat describes, "will be magnetised, and demagnetised correspondingly with the condensation and rarefaction of the mass of air," "and the armature belonging to the magnet will be set into vibrations similar to those of the membrane in the transmitting apparatus." Both inventors insisted on the necessity for an undulatory effect. Bell places it in the current as it leaves the transmitter; Reis in the magnetic field of the receiving magnet. Let us see, therefore, which explanation is the more nearly in accord with the facts as they are now generally accepted.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the meeting of this Society on Thursday, Nov. 26, Mr. Spagnoletti in the chair, Dr. J. A. Fleming, M.A., read a paper "On the Necessity for a National Standardizing Laboratory for Electrical Instruments." Dr. Fleming began by quoting a passage from the writings of Sir John Herschel with which everybody at this day must agree, namely, that, although formerly in the pursuit of individual research arbitrary standards of measurement were permissible, directly reasearch becomes general there arises the necessity for uniform standards accepted and employed by all. The early pioneers of electrical science, like Cavendish, had to devise standards of their own, which, however, had no universal adaptability. In recent years the theoretical standard had been settled, or, more correctly, an approximate agreement had been arrived at. But its identity in practice was far from complete, and the object of his paper was to suggest a central and recognised institution where the standards commonly in use could be tested, and absolute identity be insured. This had become a matter as much for the public convenience and welfare as the Yard Measure at Greenwich or the Thermometer test at Kew. Electrical industry had

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immensely increased during the last few years, especially in the field of electric lighting; yet, except at the Cavendish Laboratory, Cambridge, no sort of electrical certification corresponding to the "hall mark" on gold and silver could be obtained anywhere. Great pains, no doubt, are taken by the makers of electrical standards of measurement; but independent views still prevail as to the ampere and the volt that would not be tolerated in the case of eighteen carat gold; and owing also to the unavoidable differences arising out of different makes of instruments a great deal remains to be done before electrical measurement is brought to a condition of certainty like time and mass. No very useful result had followed the labours of the Paris Electrical Congress in this direction, the French standard and the English still maintaining their divergency. After quoting the late Prof. Fleeming Jenkin's opinion with regard to the worthlessness of uncertified copies of measures which themselves are not certified, Dr. Fleming went on to consider his proposition, first, in relation to the requirements of pure science, and then to those of electrical engineering. Unless there is absolute identity of measurement among different observers the published results of their experiments will be misleading; and in the manufacture of electrical appliances the practical inconvenience of varying standards is every day felt to be more and more serious. Everybody must admit that the highest possible uniformity is desirable; the only question was, how is it to be obtained? The establishment of a national standardizing institution would meet this want. Put in relation with such places as Greenwich and Kew, and possessing both the means of independent research and the assistance of experienced persons, such an institution would not only design the best standard instruments, but would be an authority to which all makers would resort to have their work certified. Dr. Fleming described in some detail what such an establishment should be, pointing as an illustration to Lord Rayleigh's laboratory and his methods of work. A moderate fee should be charged, and would not be grudged for certified tests conducted under such high authority. It would then be the vendor's or buyer's own fault if absolute exactness and uniformity did not soon everywhere prevail in this country. Other countries would soon follow our example. Besides this an institute of the kind he contemplated might be used for the testing of electrical materials, which varied with commercial morality as well as commercial ignorance. It would give the direction and impetus to experimental research; and would probably furnish experimental proof of many important theories which are still wanting verification. Quantitative research would not pay as a commercial undertaking, although the case of the French Academy of Science was not altogether discouaging.. This brought him to the question of funds. Many people objected to the endowment of research as generally tending to the research of endowments [laughter]; but our choice lay between private munificence and a public benefaction. There was a public fund which he thought might be appropriately applied to the object he had in view, namely the fees of the Patent Office. Through the recent Patent Act a vast increase had taken place in the number of patents taken out. In 1883 there were about 5,000 only; but in 1884 they had risen to 17,000, of which about 1,400 related to electrical inventions. The revenue from this source was very considerable; and he thought that efforts should be made by such a society as that of the Telegraph-Engineers and Electricians, backed by the Royal Society and British Association, to secure some of this money for the public endowment of an institution, the importance of which to electrical progress was growing more urgent every day. The net outcome of his paper might, in conclusion, be summed up as follows:—First, that unity of operation in this branch of science was desirable; secondly, that the standards recognised as authoritative should be lodged in some one place; thirdly, that this place would preferably be a national standardizing institution; fourthly, that the proper body to initiate the scheme would be the Society of Telegraph-Engineers; and, lastly, that the council be invited to take the matter up with the Royal Society.

Mr. CHANEY, of the Board of Trade, thought that what was needed most was, not new units or new standards, but uniformity of the measures used in the trade, especially for that of electric lighting. He gravely doubted the expediency of mixing up research with a question of this sort, and feared that the one proposal might embarrass the other. The expense of an establishment for standardizing would not be very great, and he saw no insurmountable difficulty in the way of creating and maintaining it. He was sure that the Board of Trade would listen very attentively to a proposition of that kind, and if a legal force were thought necessary to the validity of the certification, it could probably be obtained through an Order in Council.

Mr. WHIPPLE, of the Kew Observatory, agreed with Mr. Chaney in regard to the separation of the two schemes, and pointed to the adaptability of Kew for the particular object aimed at. Funds for similar tests of thermometers, watches, &c., which are certified there have been obtained by grants from the Royal Society.

Mr. JACKSON, of the Patent Office, furnished some particulars as to the number and value of electrical patent fees, which appeared to have been rather over-estimated.

Captain CARDEW thought, for his part, that what was most needed was permanency in the standards; they might be trustworthy to begin with, but the difficulty was to keep them so.

Captain SANKEY and Mr. CROMPTON spoke as to the pressing importance of some recognised standardizing, as did also Mr. PREECE, who stated that the "legal" ohm adopted at Paris having proved to be wrong, like the old standard ohm, had been abandoned by the Postal Telegraphs in this country, and their example would, he believed, be followed in the United States and by Germany.

Profs. FOSTER and ADAMS having also spoken, a resolution, proposed by Mr. C. H. W. BIGGS, calling upon the Society to take the initiative in this matter, was carried unanimously; and after the usual vote of thanks the meeting separated.

The following is the list of Council and Officers proposed to be balloted for at the next meeting of this Society. It will be seen that the Council has adopted the plan of submitting a list to the members, from which they may select their representatives:—

PRESIDENT.

Prof. D. E. Hughes, F.R.S.

VICE-PRESIDENTS.

(Four to be elected.)

Sir Charles Bright, M. Inst. C.E.
Edward Graves.
Colonel Sir Francis Bolton.
J. Hopkinson, M.A., D.Sc., F.R.S.

ORDINARY MEMBERS OF COUNCIL.

(Twelve to be elected.)

William T. Ansell, F.R.G.S.
Prof. W. E. Ayrton, F.R.S.
E. B. Bright, M. Inst. C.E.
R. E. Crompton, M. Inst. C.E.
William Crookes, F.R.S.
Prof. George Forbes, M.A., F.R.S.E.
Alexander Siemens.
Augustus Stroh.
} *Remaining on Council.*

Recommended by Council, and *four* of whom may be selected by running the other four names through with the pen:—

Captain Charles F. C. Beresford, R.E.
Shelford Bidwell, M.A., LL.B.
Captain Phillip Cardew, R.E.
Conrad W. Cooke.
J. A. Fleming, M.A., D.Sc.
Prof. John Perry, F.R.S.
W. H. Stone, M.A., F.R.C.P.
Prof. Silvanus P. Thompson, B.A., D.Sc., F.R.A.S.

ASSOCIATE MEMBERS OF COUNCIL.

Recommended by Council, and *three* of whom may be selected by running the other three names through with the pen:—

(Three to be elected.)

Colin Brodie.
W. Lant Carpenter, B.A., B.Sc.
Gisbert Kapp.
William M. Mordey.
John Munro.
P. W. Willans.

HONORARY TREASURER.

Edward Graves.

HONORARY SECRETARY.

Colonel Sir Francis Bolton.

LIGHTHOUSE ILLUMINANTS.—ELECTRIC LIGHT APPARATUS.

REPORT OF PROF. W. GRYLLS ADAMS, F.R.S., &c.

(Continued from page 60.)

Experiments in the Photometric Gallery.

On September 24th an attempt was made to compare the electric light from large 40 mm. solid carbons with the light from the pentane gas holder, altering the height of the pentane flame so as to balance the light from the electric arc according to Mr. Harcourt's scale for the pentane flame.

The photometric disc was at a distance of 138 ft. from the arc.

The mean of several observations gave the following results:—With an E.M.F. of 45·8 volts and a current of 165·7 amperes (giving 7,593 mean watts) there was a mean illuminating power of 15,300 candles, the machine employed to give the current being the L No. 1 machine. Great difficulty was found in measuring the light in consequence of the difference of colour between it and the standard.

On the evening of September 24th the current from one machine to the "A" tower was 100 amperes, and the electromotive force at the terminals of the machine was 60 volts and at the extremities of the arc on

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the lower stage was 45 volts, and at the extremities of the arc on the upper stage was 38 volts; thus, with the wires to the lower stage in the "A" tower there was a difference or loss of 15 volts, and with those to the upper stage a difference of 22 volts, wasted on the leads; showing that in the first case, *i.e.*, with the thick leads to the "A" tower the loss was one-fourth of the whole, and with the smaller leads to the "A" tower the loss was $\frac{1}{16}$, or more than one-third of the whole, in consequence of the high resistance of the leads.

On October 17th experiments were made in the photometric gallery. The electromotive force was measured at the extremities of the arc. The current was measured in the photometric gallery by a Siemens electro-dynamometer. During the evening Mr. V. Harcourt was engaged in measuring the intensity of the light by means of his pentane standard flame and the star disc photometer.

The electromotive force and current continued quite steady throughout the evening, giving a mean electromotive force of 35 volts at the extremities of the arc, and a current of 160 amperes, giving 5,550 as the mean watts.

The machines are now shown to be pretty nearly equal in their yield of electrical energy, and to work in an exceedingly satisfactory manner.

When two machines were supplying current to one arc, or even with a single machine, the carbons and the whole lamp became very hot, and had to be very frequently changed. To obviate this, at Dr. Hopkinson's suggestion, a shunt or by-pass was arranged to the lamp so as to carry a large percentage of the current direct to the lower carbon, only allowing a portion of it to go through the lamp sufficient to regulate the carbons, and keep them at their proper distance apart. This shunt is a great improvement, for with it the same lamp may be used without injury throughout a whole evening's experiments.

On October 18 two machines, L No. 1 and L No. 2, were worked together, *without being clutched*, to supply current to an arc in the photometric gallery. At Dr. Hopkinson's suggestion a shunt to the lamp had been arranged, so as to carry more current to the 40 mm. carbons without over-heating the lamp. This arrangement proved very satisfactory, and the current through the arc was much greater than had been possible before, and yet the lamp did not become unduly heated.

The average electromotive force at the terminals of the machines was 46 volts, and the electromotive force at the extremities of the arc was 36 volts, the current through the arc being 278 amperes, giving 10,022 as the watts or energy absorbed per second in the arc.

This is equivalent to 13·4 horse-power.

These experiments were repeated, and some other interesting experiments made, on October 18, when Dr. J. Hopkinson went with me to the South Foreland.

Two machines were started together, but independently, each being driven by its own belt, and they increased their speed in harmony, always going together until they reached their normal speed, when the electromotive force rose to 80 volts. The belt was now thrown off one of the machines, when the electromotive force at the terminals of the driving machine remained at 80 volts. A strap was placed round the pulley of the motor machine, and a weight of 14lb. was hung on the strap; the machines continued to run together, but the electromotive force oscillated from 80 to 78 volts as the weight rose and fell with the pull on the strap, being not heavy enough to give a steady pull. Thus one machine was being driven as a motor by another equal machine, and was doing work which was measured by the friction brake. The pulley was 16 inches in diameter, and the speed 600 revolutions, giving 35,200 foot-pounds per minute, or more than 1 horse power.

On putting on 28lb. on the pulley of the motor, the electromotive force was reduced from 80 volts to 78 volts, and remained steady, and the machines still ran together. On putting 42lb. on the brake on the pulley of the motor, the electromotive force was reduced to 76 volts, and then 56lb. was put on, when the motor continued to run at the same rate as the generator, and the electromotive force was steady at 74 volts.

On account of the heating of the extemporised brake strap, it was not thought advisable to continue the experiments by adding heavier weights, although there seemed to be every probability that the machines would continue to run together at the same speed, the one as generator and the other as motor and doing work. The above experiments show that the work done on the brake was 140,000 foot-pounds per minute, or more than 4 horse-power.

In another experiment the three machines were started together, and run up to their usual speed of 600 revolutions per minute, each machine being driven by its own belt. The belts were then thrown off two of the machines, and they were driven as motors by the current from the third machine, the electromotive force at the terminals of the third machine being the same as when the three were running together in parallel circuit.

On November 10th I again made further experiments with the three De Meritens magneto machines, and made measurements of the light given by the arc worked from the machines separately and combined in parallel circuit.

The resistance of the leads from the engine room to the photometric gallery in which the measurements were made was ·032 ohm (cold), and the leads were heated considerably, and where exposed became quite warm to the touch when carrying the current from two machines or from the three machines.

One machine alone gave a current of 175 amperes, with an electromotive force of 40 volts at the machine terminals, and an electromotive force of 33 volts at the extremities of the arc, giving 5,775 watts expended in the arc and 1,225 watts expended on the leads.

Two machines worked well together, being driven independently, and gave an average current of about 275 amperes, with an electromotive force of 47·5 volts at the machine terminals, and an electromotive force of 35·5 volts at the extremities of the arc, giving 9,750 watts expended in the arc and 3,300 watts expended on the leads.

Another experiment with two machines gave an average current of 278 amperes, with an electromotive force of 48 volts at the machine terminals, and an electromotive force of 36 volts at the extremities of the arc, giving 10,000 watts as the energy per second expended in the arc.

These experements give for

(1.) One machine—
7,000 watts (electrical energy in external circuit);
1,715 watts (electrical energy in internal circuit);
giving 8,715 watts as the total electrical energy per second.

The power absorbed, as shown by indicator diagrams, during this running, was 13·8 horse-power, or 10,295 watts, giving an electrical efficiency of 84 per cent.

(2.) Two machines—
13,300 watts in the external circuit;
1,800 watts in the internal heating of coils;
giving 15,130 watts as the total electrical energy per second.

The power absorbed was 28·53 horse-power, or 21,280 watts, giving an electrical efficiency of 71 per cent.

The electromotive force and current remained as steady as when the two machines had been mechanically connected together by clutches, completely proving that with equal machines such mechanical connections are entirely unnecessary.

This we had also found to be the case in the experiments of October 18th, when experimenting with two machines, and also with the three machines running on the same parallel circuit. The third machine has no mechanical connection with the other two machines, except through the belting, being driven from the same countershaft. When run together, the three machines gave a steady current of 300 amperes through an arc with an electromotive force of 49 volts at the machine terminals, and of 37 volts at the extremities of the arc, giving 11,100 watts expended in the arc.

On account of the high resistance and consequent heating of parts of the lamp, and the irregularity of burning of the 40 millimetre carbons employed, the current from the three machines was only about 25 to 30 amperes greater than the current from the two machines.

In the experiments on November 10th, with the three machines driven independently in parallel circuit, there was considerable variation in the mean electromotive force and in the mean current. The irregularity was due to the very unequal burning of the carbons, which was noticed at the time of the experiments, and not to any irregularity in the working of the three machines; for as the electromotive force increased the current diminished, and there was comparatively little variation in the rate of work done in the arc. In one set of experiments the electromotive force varied from 42 to 32 volts, and the current from 270 to 310 amperes, yet the product remained much more nearly constant, and the average was about 11,000 watts. In another set the electromotive force varied from 41 to 37 volts, and the current from 290 to 316 amperes, giving an average of 11,600 watts in the arc.

The belt was now thrown off the third machine, which still continued at the same uniform speed, being driven as a motor by the current from the other two machines, with the arc still in the external circuit. Thus, of three alternate-current machines arranged in parallel circuit to supply current to an external circuit, one may be run as a motor by the current from the other two, which will continue to supply an arc in the external circuit. The electromotive force at the extremities of the arc and the current through the arc were measured, and experienced wider variations than in the last experiment with three machines parallel, but the power in the arc remained very constant at about 12,000 watts, rather greater than when the three machines were driven directly from the engine. The arc also was observed to be steadier when the third machine was being driven as a motor, as though the motor acted as a governor on the circuit. The electromotive force at the extremities of the arc varied from 52 to 41 volts, with occasional readings outside these limits, and the current varied from 240 to 285 amperes, the electromotive force rising when the current diminished in such a way that the product remained very nearly constant. It would seem from these experiments that the work done in the arc with two machines combined in parallel circuit, without the third machine in the circuit at all, was considerably less than the work done when the two machines were supplying the arc, and at the same time driving the third machine as a motor.

Not only so, but when the machines were all three driven directly from the engine, the work done in the arc was rather less than the work done when the two machines were supplying the arc, and at the same time driving the third machine as a motor. These remarkable results are also borne out by the photometric results obtained during these experiments.

With the kind assistance of Mr. Longford and two of my students, Messrs. Anderson and Wordingham, I was able to measure the current, the electromotive force at the terminals of the machine and at the terminals of the arc, as well as the candle-power throughout the experiments. The photometer employed was Dr. Hopkinson's dispersion photometer, in combination with a star disc and a paraffin lamp with a Methven slit. Ruby glass and ammonia sulphate of copper solution placed before the eye were employed to compare the intensities of red and blue in the two sources of light. By the Hopkinson photometer an illuminating power of 16,000 candles was reduced to six candles within a distance of 100 inches from the arc. The illuminating power given by the arc fed by the current from one machine was measured at a distance of 50 inches from the arc, and was found to be, with red light, 8,000 times, and with blue light, 16,000 times the light of the standard light.

At the same distance, the current from two machines gave 15,000 times the standard, as measured by red light. For these and higher candle-powers it was found convenient to remove the dispersion photometer to a distance of 100 inches from the arc.

The illuminating powers given by the current from two machines were then found to be 13,500 by red light, and 23,200 by blue light.

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The illuminating powers of the current from three machines driven in parallel circuit were 16,000 by red light, and 31,000 by blue light; and when the two machines fed the arc and drove the third machine as a motor, the illuminating power was 17,300 as measured by red light.

TABULAR STATEMENT OF RESULTS.

—	E.M.F. at the arc.	Current.	Watts in the arc.	Illumination.	
				By red light.	By blue light.
With one machine ...	33	175	5,775	8,000	16,000
With two machines...	35·5	275	9,750	13,500	23,200
	36	278	10,000		
With three machines	37	300	11,100	16,000	31,000
	42 to 32	300	11,000		
	41 to 37	310	11,600		
With two machines driving the third as a motor...............	52 to 41	240 to 285	12,000	17,300	

With the large current of 300 amperes, the difference of electromotive force due to the resistance of the *leads to the photometric gallery* is 12 volts, or one quarter of the whole, and the total power of 14,700 watts is diminished by 3,600 watts from this cause.

October 18th. The 40 mm. carbons employed very soon became red-hot throughout their whole length, when three machines were employed giving a current of 300 amperes, so that it was impossible to continue the experiments long.

The diameter of the crater formed in the carbons was 22 millimetres. The light varied from 14,700 candles to 24,000 candles with two machines to one arc.

The light varied from 16,400 candles to 29,600 candles with three machines supplying the current to a single arc.

During the evening of October 18th, measurements were made by Sir J. Douglass in No. 2 hut.

The single electric light was exhibited in the "A" tower, being supplied from machine L No. 3.

The electromotive force was measured at the same time in the engine room at the machine terminals, and also in the "A" tower at the extremities of the arc. The current was about 100 amperes.

The electromotive force at the machine terminals was 45·5 volts.

The electromotive force at the extremities of the arc was 30·5 volts, showing that only about two-thirds of the available external energy was expended in the arc, one-third of the energy being wasted in the leads from the L No. 3 machine to the "A" tower. This confirms the result observed on September 24th.

On October 25th, as the photometric gallery was occupied by Mr. Harcourt, I was engaged in making measurements to determine the coefficient of self-induction of the three machines.

Taking γ as the coefficient of self-induction and T the periodic time, the value of $\frac{2\pi\gamma}{T}$ for the several machines was determined.

	$\frac{2\pi\gamma}{T}$		Internal Resistance.
For L No. 1 machine	·305 ohm	=	·044
For L No. 2 machine	·2967 ohm	=	·049
For L No. 3 machine	·323 ohm	=	·056

With these high coefficients of self-induction the machines run very steadily and are less affected by variations in the arc, and, with their small internal resistances, are exceedingly well adapted for lighthouse work, where the arc would usually be not far away from the machine; but where used with long leads of considerable resistance, as at the South Foreland experiments, the loss of energy is great in consequence of the small internal resistance of the machines.

November 8th. In the previous determinations of the intensity of the electric light, the light was compared with standards of one or of about three candles, at distances from the arc varying from 140 to 350 feet from the arc.

On November 8th I made some experiments with Hopkinson's dispersion photometer, consisting of a small convex lens of 1·933 inch focal length, fixed in a tube fitted with diaphragms so arranged that a small beam from the arc entering the tube fell upon the lens. This lens brought the light to a focus, which became the source of light for the illumination of the Bunsen disc, and which was compared with the Douglass standard lamp.

The slit was arranged so as to give an illumination of one candle at a distance of one foot. When the lens was placed at a distance of 8 feet 6 inches, or 102 inches from the arc, the dispersive power of the photometer reduced an illuminating power of 16,000 candles to a focus giving an illuminating power of about six candles.

The power of the lens being

$$\left(\frac{f}{u-f}\right)^2 = \left(\frac{1\cdot933}{100}\right)^2 = \cdot0003738, \text{ or } \frac{1}{2,675},$$

or the multiplying factor being 2,675.

(To be continued.)

BRITISH ASSOCIATION.

Report of the Committee, consisting of Prof. G. FORBES, Captain ABNEY, Dr. J. HOPKINSON, Prof. W. G. ADAMS, Prof. G. C. FOSTER, Lord RAYLEIGH, Mr. PREECE, Prof. SCHUSTER, Prof. DEWAR, Mr. A. VERNON HARCOURT, and Prof. AYRTON, appointed for the purpose of reporting on Standards of White Light. Drawn up by Prof. FORBES.

The experimental work of the Committee during the past year has not been extensive, as they had no funds at their disposal for experimental research, and they have been chiefly occupied with reviewing what has been done in the past and laying plans for future operations.

Lord Rayleigh has constructed an instrument which he calls a monochromatic telescope, by means of which the illuminated screens of a photometer may be examined, allowing light only of one definite colour to pass. It was hoped by Lord Rayleigh that experiment might show that, with some suitably chosen colour, this instrument, used with any ordinary photometer, would, in comparing lights of different intensities and temperatures, give to each a candle-power which would be sufficiently accurate to represent for commercial purposes the intensity of the light. The secretary has made some experiments at the Society of Arts, where he was kindly permitted to use the secondary batteries and glow lamps; but the results so far are not definite enough to justify their publication.

Mr. Vernon Harcourt has been engaged on an investigation on the barometrical correction to his pentane standard, and on another concerning the possibility of using lamp shades as a protection from air currents. His researches are communicated independently to the meeting.

Captain Abney and Colonel Festing have continued their observations on the intensity of radiations of different wave-lengths from incandescent carbon and platinum filaments at different temperatures.

Other isolated experiments have been made by members of the committee, which will be published in due course.

Most of the members have examined the experiments of the Trinity Board at the South Foreland.

Existing Standards.

A consideration of existing standards convinces the Committee that the standard candle, as defined by Act of Parliament, is not in any sense of the word a standard. The French "bec Carcel" is also liable to variations; and with regard to the molten platinum standard of Violle, it seems that the difficulty of applying it is so great as to render its general adoption almost impossible.

With regard to the so-called standard candle, the spermaceti employed is not a definite chemical substance, and is mixed with other materials, and the constitution of the wick is not sufficiently well defined. Hence it is notorious that interested parties may prepare candles conforming to the definitions of the Act which shall favour either the producer or consumer to a serious extent. In view of these defects of the standard candle, it is a matter of great importance that a standard of light should be chosen which is more certain in its indications.

The Committee have looked into the merits of different proposed standards, and the majority feel satisfied that, for all the present commercial requirements, the pentane standard of Mr. Vernon Harcourt—since it has no wick and consumes a material of definite chemical composition—when properly defined, is an accurate and convenient standard, and gives more accurately than the so-called standard candle an illumination equal to that which was intended when the Act was framed.

Yet the Committee, while desiring to impress the Board of Trade and the public with these views, do not feel inclined at present to recommend the adoption of any standard for universal adoption until, further information on radiation having been obtained from experiment, they may learn whether or not it may be possible to propose an absolute standard, founded, like electrical and other standards, on fundamental units of measurement—a standard which, for these reasons, would be acceptable to all civilised nations. They are, however, inclined to look upon the pentane lamp as an accurate means of obtaining an illumination to replace the so-called standard candle.

Proposed Experimental Researches.

Radiation is measured as a rate of doing work, and consequently radiation might be measured in watts. The illumination (or luminous effect of radiation) depends partly upon the eye, and is a certain function of the total radiation. This function depends upon the wave-length of the radiation, or on the different wave-lengths of which the radiation, if it be compound, is composed. This function of the radiation perceived by the eye is partly subjective, and varies with radiations of different wave-lengths and with different eyes. Thus the illumination cannot, like the radiation, be expressed directly in absolute measurement. But the connection between the illumination and the radiation can be determined from a large number of experiments with a large number of eyes, so as to get the value of the function for the normal human eye. This function, however, is constant only for one source of light, or, it may be, for sources of light of the same temperature. It appears, then, that, in the first instance at least, a standard should be defined as being made of a definite material at a special temperature.

The energy required to produce a certain radiation in the case of a thin filament of carbon or platinum-iridium heated by the passage of an electric current can be easily measured by the ordinary electric methods, and the radiation may be measured by a thermopile or a bolometer, which itself can be standardised by measuring the radiation from a definite surface at 100° C., compared with the same at 0° C. The electric method measures the absorption of energy; the thermopile measures the total radiation. These two are identical if no energy is wasted in convection within the glass bulb of the lamp, by reflection and absorption of the glass, and by conduction from the terminals of the filament. Captain Abney and Colonel Festing have come to the conclusion that there is no sensible loss

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from these causes. The committee propose to investigate this further. This constitutes a first research.

No research is necessary to prove that with a constant temperature of a given filament the luminosity is proportional to the radiation, because each of these depends only upon the amount of surface of the radiating filament. It will be necessary, however, to examine whether with different filaments it be possible to maintain them at such temperatures as shall make the illumination of each proportional to the radiation. This will be the case if spectrum curves, giving the intensity of radiation in terms of the wave-length when made out for the different sources of light, are of the same form. Thus a second research must be undertaken to discover whether the infinite number of spectrum radiation curves, which can be obtained from a carbon filament by varying the current, are identical in form when the filament is changed, but the material remains so far as possible of constant composition.

It will be an object for a later research to determine whether, when the radiation spectrum curve of any source of light has been mapped, a similar curve can be found among the infinite number of curves which can be obtained from a single filament.

The next step proposed is to examine a large number of carbon or of platinum-iridium filaments, and to find whether the radiation spectrum curve of different specimens of the same material is identical when the resistance is changed in all to x times the resistance at 0° C. If this law be true a measurement of the resistance of the filament would be a convenient statement of the nature of the radiation curve. If, then, a number of filaments were thus tested to give the same radiation spectrum curve, their luminosities would in all cases be proportional to their radiations, or (if there be no loss in convection, conduction, absorption, and reflection) proportional to the electrical energies consumed.

Thus it might be hoped to establish a standard of white light, and to define it somewhat in the following manner :—*A unit of light is obtained from a straight carbon filament, in the direction at right angles to the middle of the filament, when the resistance of the filament is one half of its resistance at 0° C, and when it consumes 10^9 C.G.S. units of electrical energy per second.*

Since Mr. Swan has taught us how to make carbon filaments of constant section by passing the material of which they are composed through a die, it is conceivable that another absolute standard should be possible—viz., a carbon filament of circular section, with a surface, say, $\frac{1}{100}$ square centimetre, and consuming, say, 10^9 C.G.S. units of energy per second.

Whether such standards are possible or not depends upon the experiments of the committee. The probability of success is sufficient to render these experiments desirable.

Proposed Later Experimental Researches.

Should these hopes be realised, and an absolute standard of white light thus obtained of a character which would commend it to the civilised world, it would then become an object of the committee to find the ratio of luminosity when the radiation spectrum curve of the standard filament is varied by varying the current, and consequently the resistance of the filament.

Thus, by a large number of subjective experiments on human eyes, a multiplier would be found to express the illumination from the standard lamp, with each degree of resistance of the filament.

A research, previously hinted at, would then be undertaken—viz., to find whether the radiation spectrum curves of all sources of illumination agree with one or other of the curves of the standard filament. It is not improbable that this should be the case except for the high temperature of the electric arc.

Should this be found to be true, then photometry would be very accurate, and the process would be as follows :—*Adjust the standard filament until its radiation spectrum curve is similar to that of the light to be compared.* (This would probably be best done by observing the wave-length of the maximum radiation, or by observing equal altitudes on either side of the maximum, the instruments used being a spectroscope and a line thermopile or a bolometer). The total radiation of each is then measured at equal distances by the thermopile. The resistance of the filament is measured, and its intensity in terms of the unit of white light obtained therefrom by the previous research. The luminosity of the compared source of light is then obtained directly.

The committee desire to be reappointed, and to enable them to carry out the researches indicated they ask for a grant of £30.

LEGAL.

Alleged Infringement of Edison's Patent.

In the Chancery Division, yesterday, before Mr. Justice Kay, an interlocutory application was made by the United Telephone Company against Mr. A. F. St. George, for an injunction to restrain the manufacture and sale of an instrument alleged to be an infringement of the plaintiff's patent of a telephone. Mr. Aston, Q.C., and Mr. Micklem were for the plaintiffs; Mr. G. Hastings, Q.C., and Mr. Bousfield for the defendant. At the close of the arguments,

The JUDGE said Edison's patent had been the subject of a great deal of litigation. It had been supported in its present form in an action in this country, and it had been construed in the plaintiff's favour in proceedings in Scotland. The validity of the patent was not now in question, but the owners of it sought to restrain an alleged infringement. The learned Judge described the operation of Edison's tension regulator, and quoted the remarks of Lord Justice Fry in respect to it, when he was a judge of first instance. That learned Judge decided that Edison's patent of regulator was not confined to a particular form. In the present case, instead of having a substance in itself compressible brought in contact with the diaphragm, or an incompressible substance applied to the diaphragm by means of a spring, they had applied to the diaphragm an incompressible substance, by its being placed in such a position that the effect of gravity brought it and kept it in contact with the diaphragm. The question he had to determine was whether that was substantially the same thing as Edison's patent. In the case in Scotland, what was determined to be an infringement was a diaphragm to the underside of which were attached two little rolls of carbon, against which lay the tension regulator in the form of other pieces of carbon hung up by bits of string, so that the effect of gravity was to bring them in contact. That was as nearly as possible identical with the defendant's arrangement, only in the latter case, instead of there being little rolls of carbon brought into contact with two scrolls attached to the diaphragm, there was a carbonised diaphragm, and in combination with it a little ball of carbon hung in such a way that, by the action of gravitation, it lay against the diaphragm. It had been decided by the authority in Scotland, from which he could not very readily dissent, if he did not agree with it, but with which he entirely agreed, that the form he had described was to all intents and purposes identical with, and was not substantially different from, Edison's invention. The defendant said while his instrument was in operation there was a make and brake of contact, but he did not say that by means of this make and break there was a transmission of vocal sound. On the contrary, Sir William Thomson, Mr. Imrie, and Prof. Hopkinson, stated in the affidavits that the transmission of intelligible speech was impossible while there was such make and break of electric continuity, and Mr. Hills stated that there was sometimes a blurring and buzzing sound in the instrument, but when the voice was clear and distinct there were no sparks, consequently no make and break. Where a patent had been established it was a great injury to a patentee to have people infringing his patent, and saying, "We will go on infringing the patent until the trial of the action." To his (the Judge's) mind there was no substantial question in this action for trial. On the evidence before him the conclusion was absolutely irresistible that this was a plain infringement of the plaintiff's patent. Accordingly he felt bound to grant an injunction to restrain the manufacture and sale of any more of the defendant's instruments between the present time and the trial of the action.

Mr. ASTON asked that the defendant might be restrained from advertising that he could sell.

The JUDGE said that was another matter, and was not now before him.

Provincial Brush Electric Light and Power Company v. Shillingford and Company.

In the Queen's Bench Division, yesterday, before Mr. Justice Field, an action was brought against a firm of brewers at Witney, Oxfordshire, for £53. 17s. 2d., being the balance of an account for the installation of the electric light at the brewery.

Mr. CUNNINGHAM was for the plaintiffs, and he put in the correspondence with a view to establish a contract between the parties.

The JUDGE said there was no contract disclosed in the correspondence, and the action would resolve itself into one for work done and goods supplied. The phrases occurred in the correspondence :—"We are quite willing to guarantee that the light shall be a success;" and "in guaranteeing a successful installation," &c. The plaintiffs therefore had to make out a successful installation.

Mr. J. ROSE said the plaintiffs were not to be paid unless the installation was successful, and the defendants made the following charges against it :—That the brushes and filaments wore out too rapidly; and the connection between the lamps was insufficient, and the lamps were faulty in construction. When complaint was made of the lamps, another set was supplied; and while the first set, giving a fair light, had too short a life, the next set had a longer life, but gave a very poor light. The erection of the fuses for the automatic cut-outs was careless, so that the batteries had been too highly charged and too rapidly discharged. Also the accumulators were insufficient for the current and the number of lights.

Mr. CUNNINGHAM said he admitted that at one period the lighting was not satisfactory.

The JUDGE said that being so, the question remaining to be solved was, whether the installation had been defective, or there had been a mis-user of it by the defendants.

The case was not completed at the rising of the Court.

The Maxim-Weston Electric Co. v. Thomas.

In the Queen's Bench Division, on Monday and Tuesday last, before the Lord Chief Justice and a Special Jury, a claim was made by the Maxim-Weston Company against the lessee of Covent Garden Theatre. The parties entered into a contract in July, 1884, for the lighting of the Floral Hall by 20 large arc lamps of 1,400 candle-power and 360 incandescent lamps during the continuance of the promenade concerts of 1884, for which £30 a week was to be paid. It was found that the light was insufficient, and subsequently seven additional arc lights were supplied, for which the plaintiffs now sought for payment. When the agreement was prepared the defendants asked that a guarantee should be inserted in it that the plaintiffs should give a good and efficient light, but the plaintiffs refused to sign the contract with that guarantee.

Mr. H. Watt, the plaintiff's manager, said within a week of the opening of the hall they were called upon to supply first four, and afterwards three additional arc lights, which they did, and the cost of them to the company was between £3 and £4 per week. They charged the defendant for these extra lights at the rate of £5 per week for the season of between fifteen and sixteen weeks.

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Mr. WILLIS said the question was whether the extra lights were ordered under such circumstances as to make the defendant liable.

Witness said the understanding was that if the plaintiffs would make the lighting satisfactory Mr. Thomas would pay.

Correspondence was put in, which showed that the defendant repudiated having ordered extra lamps, but claimed that the original contract was that the Floral Hall should be properly lighted, and all he did was to suggest how this might be done.

At the close of the plaintiffs' case Mr. WILLIS addressed the jury for the defendant. He said differences arose between the parties about the terms of the advertisement, and ultimately they stood thus:—"The Floral Hall, the coolest and best-lighted place of amusement in Europe, illuminated by the Maxim-Weston Electric Company." The defendant wrote that it was far from being what was described. The plaintiffs wrote that the installation cost a great deal of labour, and would not pay them at a less charge than £50 a week. The defendant replied that it was idle to ask him to pay extra for what the plaintiffs contracted to do, and that he did not care what kind of lamp was employed so long as he got a proper light and was able to save gas.

The JUDGE, in the summing up, pointed out that the agreement contemplated the electric light not being sufficient, because if it had to be supplemented by gas the plaintiffs were to pay for the gas; but nothing was said in the agreement about additional electric lamps beyond the twenty arcs specified. In his opinion the defendant was not entitled to go behind the agreement of July 21st, by which both parties must be bound. He would ask the jury to answer two questions:—First, was there ever in fact an agreement between the parties that four lights beyond the twenty should be put up by the plaintiffs free of cost? And, secondly, was it ever agreed that three lights beyond the four extra should be supplied by the plaintiffs free of cost? Did the correspondence show that there ever was an independent contract or understanding that, as regarded any arcs, except those specified in the agreement, they should be included in the £30 a week?

The Jury found for the plaintiffs for £80, having answered both the questions in the negative.

Counsel asked for a stay of execution, but the Judge said there was no reason for such a step, and he gave judgment in accordance with the verdict.

Wheatley v. The Consolidated Electric Light Co.

In the Chancery Division of the High Court of Justice on Monday and Tuesday last, the hearing of this case was resumed. It was an action to restrain a nuisance of noise and oscillation occasioned by the working of the defendants' machinery upon premises separated only by a party wall from the dining room of the Three Compasses, Cow Cross-street, Smithfield.

Mr. Ingram, a consulting engineer, of Queen Victoria-street, said he visited the premises on the 23rd November, and by tests ascertained that the oscillation in the dining room corresponded with the beating of the machinery on the adjoining premises. He heard three distinct noises. The vibration was communicated to the party wall by means of the iron girders which supported the shafting. In cross-examination witness said the erection of a separate wall, as had been suggested, would diminish the area of the defendants' premises, but it would not necessitate the moving of the machinery, as the bands could be shortened.

Mr. MILLAR, for the defendants, contended that the plaintiff's business was itself a noisy one, and carried on in perhaps the noisiest spot in London. There was also noise from the neighbouring railway line, along which heavy luggage trains were constantly passing. The plaintiff went to the noises; they were not brought to him. If the noise had slightly increased, Wheatley was not the man to complain, as he was only a weekly tenant at £5 a week, the tenancy being terminable at a month's notice. He paid nothing for the goodwill, and neither the leaseholder nor the freeholder interfered in the matter. The previous tenant paid £500 a year, and died insolvent; the business was therefore derelict when the plaintiff took it, and the further falling off in the profits was due to the stagnation of trade. The machinery ran only three hours a day. He (Mr. Millar) did not deny the existence of noise, but it was not such a noise as entitled the plaintiff to damages.

Mr. G. Forbes, civil engineer, Westminster, said he visited the premises at the request of the defendants in February of this year, and found that the noise in Cow Cross street was greater than that made by the machinery. The vibration was imperceptible, except when the hand was placed upon the party wall. The plaintiff's dining room was a remarkably quiet room when no traffic was passing, and a whisper could be heard distinctly from one end of the room to the other.

Mr. Ashby, builder, said it was possible to erect a separate wall, but it was scarcely practicable, and would be very inconvenient. The walls throughout would have to be altered, and the girders would have to be cut.

The JUDGE: A gentleman told me yesterday that the noise could be stopped with eiderdown.

Witness: Possibly, but I would not use that material.

Mr. G. Offor, the manager of the defendant company, said he accompanied the directors on their visit to the plaintiff's premises, and they came to the conclusion that their was no ground whatever for the complaint.

Several other witnesses gave evidence to the same effect—that there was no nuisance whatever.

After counsel on both sides had addressed the Court,

The learned VICE-CHANCELLOR said the plaintiff had fully made out his case, that a nuisance was occasioned by the defendants' engines and dynamos. It was admitted by both sides that the traffic in Cow Cross-street and the passing trains made some noise but that was no reason why the defendants should go there and make more noise, which was heard above the neighbouring noises. It was proved by the defendants' own witnesses that the working of the machinery had created noise and vibration. The mischief could, moreover, be remedied in a few hours, if the defendants were willing to do so. There must be an injunction.

By arranyement between the parties, the order was suspended for a month.

United Telephone Company v. Townson and Mercer.

On the 27th ult., in the High Court of Justice, Chancery Division, before Vice-Chancellor BACON, Mr. ASTON, Q.C., applied for an interim injunction, on the ground that the defendants had sold a Bell telephone in separate parts, which, however, anybody could put together at any time. To sell a telephone in separate pieces was substantially to sell the patentee's telephone. A correspondence had taken place between the parties, and the defendants' solicitors had written that they would consent to the injunction, and had instructed counsel to consent also to damages, subject to a settlement being arrived at in regard to them. One of the essential clauses in the arrangement of such cases was that the costs incurred by the plaintiff up to the time of the settlement, should be paid on the scale of costs between solicitor and client. This was what he (Mr. Aston) asked in the present case.

Mr. WILKINSON, for the defendants, said he would agree to the injunction being made perpetual, but the question of costs was left by the Act in the discretion of the Judge; and he urged that the defendants should only be called upon to pay the costs between party and party. He made this offer last week, when the plaintiffs refused it, and costs had since been incurred quite unnecessarily.

The VICE-CHANCELLOR, in granting a perpetual injunction, said the policy of the Act was that if a patentee was put to the trouble of bringing more than one action, after he had established his right, the infringer should pay the solicitors' and clients' costs. That must be the order in this case.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. DEC. 2.		BUSINESS DONE WEEK ENDING DEC. 2. Highest.	Lowest.
Anglo-American	31½,	32½	33¼	30½
Do. Preferred	52½,	53½	55½	50¼
Do. Deferred	9,	10	10½	8¾
Brazilian Submarine	10¾,	11	11	10 13-16
Cuba	11,	12	12¼	11
Do. Preference	18,	19	19	—
Direct Spanish	1½,	2	1½	—
Do. Preference	11½	12	—	—
Direct United States Cable	9⅜,	9⅝	9½	9⅛
Eastern Telegraph	11⅝,	11⅞	11⅞	11 11-16
Do. 6 per Cent. Preference	13½,	14	13¾	13½
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅞,	13⅛	13⅛	12⅞
German Union	9½,	10	—	—
Globe Telegraph and Trust	6¾,	7⅛	7⅛	6 15-16
Do. Preference	13¼,	13½	13½	13⅜
Great Northern	13¾,	14⅛	14½	14 1-16
Indo-European	82,	83	—	—
Reuter's	7,	7½	—	—
Submarine	205,	215	207½	—
West India and Panama	⅞,	1	15-16	⅞
Do. 1st Preference	8¼,	8¾	9¼	8 7-16*
Western Brazilian	5⅜,	5⅞	5¾	—
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

* x.d. 9s., on account of arrears.

TELEPHONES.

Consolid. Telephone and Maintenance	⅞,	1	15-16	—
Oriental	3-16,	5-16	—	—
United Telephone	12,	12½	12½	12⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3,	3½	3¼	—
Do. (fully paid)	4½,	5	5	4⅝
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1,	1¼	1¼	1 3-16
Maxim-Weston	¼,	⅜	—	—

MISCELLANEOUS.

Telegraph Construction	36½,	37	37⅛	36¾
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24¾	24¼

TRAFFIC RECEIPTS FOR NOVEMBER, 1885.

COMPANIES.	Nov., 1885.	Nov., 1884.	Increase.	Decrease.
Direct Spanish Telegraph	2,021	1,729	292	—
Eastern Extension	40,427	42,286	—	1,859
Eastern Telegraph	56,245	55,640	605	—

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NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 4th December amounted to £3,376.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ending November 30th amounted to £3,775.

ENGLAND AND BURMAH.—Advices from Thyetmyo, dated December 9th, state that telegraph communication with the frontier will probably be restored within four or five days.

EASTERN EXTENSION TELEGRAPH COMPANY.—An interim dividend for the quarter ended September 30th of 2s. 6d. per share has been declared by this company, payable on the 15th prox.

ITALY AND THE RED SEA.—It is announced that a contract has been signed between the Italian Government and Pirelli and Co., of Milan, for laying down a cable between Massowah and Perim.

HEALTH AND THE ELECTRIC LIGHT.—Under the above title a lecture was delivered last night (Thursday) by Mr. Eric S. Bruce at the Parkes Museum of Hygiene, Margaret-street, Regent-street, W.

AT THE NEW CIRQUE.—The installation of the new Cirque Dela Rue Saint-Honoré, Paris, is being rapidly pushed forward. During the last eight days work has been carried on at night, thanks to the Edison light.

AT THE OPERA.—On Saturday last at the Paris Opera House the *loggia* was electrically lighted for the first time. The large vestibule which gives access to the grand staircase is illuminated by 10 Pieper arc lamps.

BRUSSELS.—The Special Commission deputed to examine the different systems of lighting proposed for the new council room of the Belgian Chamber of Representatives at Brussels have decided to adopt the incandescent light.

TELEGRAPH LEARNERS.—The Civil Service Commissioners notify that an examination for the Telegraph Service of the General Post Office will shortly take place, applications to be received not later than 28th inst. Age, 14 to 18.

THE ELECTRIC LIGHT AND THE NEW PARLIAMENT.—The *Standard* states that among the minor legislative proposals which have been under the consideration of the Government is one dealing with the subject of the Electric Lighting Act.

THE TELEGRAPH BATTALION.—On Wednesday evening Lieutenant F. G. Bowles, Royal Engineers, and six clerks of the Second Telegraph Battalion, received orders at Aldershot to hold themselves in readiness to proceed on service to Egypt.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 4th December were £2,576, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for November were £22,800. In the period from 1st January to 30th November the receipts were £264,440; against, in the corresponding months of 1884 and 1883, £257,480, and £236,480 respectively.

AN ELECTRIC LAUNCH FOR ITALY.—Messrs. Yarrow and Co., of Poplar, have received an order from the Italian Government for a launch, to be propelled by electricity, for Spezia Dockyard, where it will be tested specially with a view to determine the merits of this system of propulsion for torpedo boats.

ELECTRIC SIGNALLING FROM BALLOONS.—We are informed that Mr. Eric S. Bruce, whose experiments in electric signalling from balloons have been noticed in our columns, is now supplying balloon apparatus to the Government, his method having been favourably reported upon by the officials deputed to examine it.

A CORRECTION.—We learn that the information published in our last issue respecting the total destruction of the Simplex Company's works by fire is incorrect. The fire was fortunately confined to the store rooms and office; and although it has caused temporary inconvenience, will not interfere with the business the company has in hand.

VIOLENT STORM IN GENEVA.—A telegram from Geneva, dated Tuesday night, announces that a thunderstorm of remarkable violence raged there on Monday evening, accompanied by a hurricane and a deluge of rain. The lightning was magnificent, and the thunder like the discharge of a park of artillery. Considerable damage has been done by the storm.

H.M.S. "INFLEXIBLE."—A few months since a scheme for the illumination of the turret ship "Inflexible" by electricity was forwarded to the Admiralty. The plans have now been returned as rejected, owing to the unsatisfactory disposition of the searchlights and projectors. It is not suggested that any improvement to the scheme of internal lighting will be required.

PERSONAL.—We regret to notice amongst the names of the old members of Parliament who have lost their seats in this election that of Mr. John Pender, who has been defeated for the Wick Burghs by a small majority.—Capt. M. H. G. Goldie, R.E., has been appointed Instructor in Army Signalling and Telegraphy to the Sappers and Miners in the Bombay Presidency.

A NEW PRIMARY BATTERY COMPANY.—According to the prospectus of the Chemical Electric Light and Power Company, of Boston, Mass., their cells, measured after six hours' work on closed circuit, give the following results: Electromotive force = 1·6 volt, current = $5\frac{1}{2}$ amperes, internal resistance = $\frac{7}{100}$ ohms. We are not acquainted with the nature of the solution.

HURRICANE ON THE COAST OF PANAMA.—Telegrams from Panama report a serious hurricane off the coast of Aspinall. Several vessels have been wrecked, and the railroad has been damaged. Telegraphic communication is also interrupted, delaying the despatch of more precise information as to the extent of the damage. It is feared that many lives have been lost at Colon.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—We are informed that the directors of this company declared on the 9th inst. an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income tax, for the quarter ended 30th September last, and payable on the 24th inst. The books of this company will be closed from the 17th to 23rd inst., both days inclusive.

THE ELECTRIC LIGHT IN THE MIDLANDS.—The adoption of the electric light for the illumination of works is extending in the Midlands. Messrs. John Lysaght, Wolverhampton, have just had the whole of their extensive Swan Garden Works fitted up upon the incandescent system. Messrs. Elwell and Parker, Wolverhampton, have supplied two dynamo machines, each capable of supplying 200 lamps, of 20 candle-power.

TELEPHONE POLES WANTED.—The directors of the Lancashire and Cheshire Telephonic Exchange Company are prepared to receive tenders for the supply of larch and creosoted poles during the year ending 31st December, 1886. Forms of tender may be obtained upon application at the head office,

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Manchester, and all tenders must be sent in not later than Tuesday morning, 15th inst.

BLACKPOOL.—At a recent meeting of the Blackpool Town Council the Highways Committee recommended that the Promenade be lighted by the electric light from the 24th inst. inclusive, for the succeeding ten days. The recommendation was adopted. Mr. J. Wolstenholme, borough surveyor, was formally appointed engineer of the Corporation, of and for the Blackpool Corporation Tramways, in place of Mr. T. Sunderland.

THE TELEPHONE AND RADIANT HEAT.—In a note recently presented to the Académie des Sciences, M. Mercadier submitted the results of his experiments with the action of radiant heat upon an elastic body, under the conditions of rythmic intermittence. He has ascertained that in such cases the heat rays have a sensible effect upon the diaphragms of the telephone and microphone, causing the latter to give out audible sounds.

A RAMPANT ACCUMULATOR.—In its issue of the 3rd inst. *The Times*, speaking of unelected former members of Parliament, says: "Indeed it is somewhat terrifying to think of all this power let loose from the restraining bounds of the House on it and on the community. The effect may be like the despatch of a vast dynamo accumulator, silenced by its neighbours in one quarter, to run wild about the town." This is, to say the least of it, vague.

SOCIETE BELGE D'ELECTRICIENS.—The annual general meeting of this society took place on the 1st instant, when M. Delarge, *ingénieur en chef directeur des télégraphes*, was unanimously elected president in the room of M. Rousseau. After the secretary, M. Charles Mourlon, had reported upon the proceedings of the society during the current year, the following gentlemen were elected members of council:—MM. Bède, Collard, De Cazenave, Bouquié, Lebègue, Northomb, Rousseau, Van der Mensbrugghe and Wybauw. The number of members of the society is now 253.

INGREY, POORE AND LATHAM (LIMITED).—This is the conversion to a company of the business of electric engineers, agents, and merchants, and electric light apparatus contractors, carried on by Charles Ingrey and Graydon Poore, at 49, Queen Victoria-street. It was registered on the 20th ult., with a capital of £4,000 in £10 shares, with power to increase. An agreement of the 17th ult. regulates the purchase, the consideration being £2,500 in fully paid shares and a sum in cash not exceeding £150 in payment of debts due by the vendors up to the 1st October. Registered without special articles.

THE EASTERN TELEGRAPH COMPANY.—This company announce the payment on 14th January next of interest at the rate of 3s. per share on the preference shares of the company, less income-tax, for the quarter ending 31st December, 1885; and that on the same day an interim dividend will be paid of 2s. 6d. per share in respect of profits for the quarter ended 30th September, 1885, with a bonus of 1s. per share for the half year ending at that date, on the ordinary shares of the company, both free of income-tax. The register of transfers will be closed from the 6th to the 14th January, 1886, both days inclusive.

POST OFFICE ORPHAN HOME.—The annual concert in aid of the funds of this deserving institution will take place tomorrow evening, in St. James's Hall, under the conductorship of Signor Alberto Randegger. The entertainment, which is of such an ample description that it is announced to commence at a quarter to eight, is under the patronage of the Dukes of Edinburgh, Cambridge, Teck, Norfolk, and Bedford, the Earl of Derby, the Postmaster-General, the Lord Mayor, and a number of the officials of the Post Office. Tickets (by which alone admission can be secured) are to be obtained of the secretary, Mr. J. Avery, E.C.D.O., General Post Office, and from members of the institute. The manager is Mr. W. Henfrey, Post Office, Vere-street, W.

BOOKS RECEIVED.—"Inventions and How to Patent Them: A Practical Guide to Patentees." By T. Eustace Smith. London: W. H. Kelly. The object of this book is to place clearly before an inventor all the information that is necessary to protect his invention and to become his own patent agent. "Calvert's Mechanics' Almanack and Workshop Companion for 1886." London: John Heywood. Contains, in addition to the usual matter of an almanack, practical, technical, an industrial information especially instructive and entertaining to artisans and handicraftsmen and those generally engaged in mechanical, engineering, building, and constructive trades, &c. The almanack is well illustrated, and will be found to be a handy little work.

THE TELEPHONE IN MINES.—The Northern District Telephone Company of Sunderland have issued a circular in which they say:—"This company, taking into consideration the great number of collieries situated in the district for which they hold their license, and feeling the great importance of efficient telephonic communication in mines, have decided to supply instruments for this purpose at exceptionally low rates. The great utility of these instruments in cases of accidents has been amply demonstrated at Usworth Colliery, and during the flooding of the Margaret Pit. The value of instantaneous communication between, for instance, the manager's house and the colliery office, and from the colliery office to the bottom of the shaft and the various parts of the workings can hardly be over-estimated."

THE ELECTRICAL CONDITION OF THE HUMAN BODY.—M. Wolff, who has recently published in the *Deutsche Médicinische Wochenschrift* an article upon a new application of electricity to the diagnosis of certain diseases, concludes that the presence of a quantity of liquid in the human body has a very sensible effect upon its resistance. He cites the case of a person suffering from pleurisy in its most violent form. The side affected gave a much larger deflection, or in other words had a lesser resistance than the other. Another observation of M. Wolff's which is not without its value is that, of all parts of the body, the cheeks are the best conductors of electricity, and that the palms of the hands and the soles of the feet are greatly inferior to them in conductive value. It would be interesting to learn the conditions under which M. Wolff made his observations.

INDIGNANT.—Our excellent contemporary, *Electricité*, feels that we are neglecting M. Marcel Deprez. It says:—"The brothers Rothschild are about to make arrangements for the exploitation of the wonderful discoveries of M. Deprez. *The obscure and envious electricians* who for a long time past have been attempting to negative the importance of the experiments at Creil, and who have declared their realisation impossible, must now admit that the transmission of force is a *fait accompli.*" The daily papers also state that Messrs. Rothschild Brothers have officially notified to the French Syndicate of Electricity that they have resolved to form a company for working the newly invented system of transporting force by electricity. The success of the recent experiments between Creil and Paris has, it is understood by our contemporaries, led to this resolution.

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SIMULTANEOUS TELEGRAPHY AND TELEPHONY IN FRANCE. The telephonic service between Paris and Rheims was opened, as before announced, on the 1st inst. The lines which are connected with the telegraphs are two in number, permitting of two distinct and simultaneous telephonic communications. At Paris offices other than that at the Bourse are not yet established, but at Rheims communication is maintained from ten different places. One of the telephone circuits is composed of two aerial lines of a diameter 4mm., and of 8 kilometres (4·96 miles) of cable; the other circuit consists of two aerial lines 5mm. diameter, and a cable of the same length as before. The length of the aerial lines is 172 kilometres (106·64 miles) of wire; the cable carries the line to an effective distance of 217 kilometres (134·54 miles), so that in the circuit there is a total of 434 kilometres (269·08 miles) of line. The Van Rysselberghe system is employed.

EARTHQUAKES.—Earthquake shocks were felt on the night of the 3rd inst. and early on the morning of the 4th inst. in Algeria, the direction of the oscillations being from north to south. Light at Algiers and on the coast, the movement became more pronounced in the interior of the country, particularly at Blidah, Menerville, Aumale, Boghara, and Boussada. At the two last-named places several houses were wrecked. At Medeah the shocks, which were very violent, lasted some time. Thirty-two persons were killed by the fall of houses at Msilah, and the residence of the chief official at Bordi-Serpant was wrecked, burying several Europeans under its ruins. Again, on Saturday, five distinct shocks of earthquake occurred at Boussada, destroying the Presbyterian Church and seventy-one dwellings. Two persons were killed, and two others received injuries. Advices from Paris state that four new shocks of earthquake were felt on Wednesday at Msilah, in Algeria, the town which suffered so severely from the same cause last week.

NEW YORK UNDERGROUND WIRE COMMISSION.—In view, says an American contemporary, of the many complaints that are being made of the dilatoriness of the commissioners appointed to enforce the Underground Wire law, the Mayor recently wrote to the Corporation counsel, asking if, in his opinion, the amendments passed by the last Legislature extended the time for putting the wires underground, and also whether the city authorities had any power to act in the matter. It will be remembered that by the original Act all electric wires were to be placed underground by 1st November last. The Corporation counsel thinks it very doubtful whether it was the intention to extend the time fixed by the original Act. He says:—"This statute will undoubtedly have to be construed by the Courts," and adds that the city authorities are relieved from all responsibility of enforcing the Act. The appointment of commissioners entirely unfitted for the work before them is a misfortune to the public, to say the least, and it is still more unfortunate that there is no authority to whom these men are immediately accountable.

THE ELECTRIC LIGHT FOR LANTERNS.—An incandescent electric light, worked by a battery possessing a reasonable degree of portability, has been successfully applied to lantern illumination. At a recent meeting of the Camera Club, the hon. secretary exhibited an application of the electric light which, in that particular respect, has been frequently attempted before, but never successfully so. The batteries occupied a box, rather under 2ft. in length and half that width, upon which a pair of lanterns was erected. This box protected two cells, and in these were immersed a number of plates of zinc and carbon, the mechanical arrangement being such as to provide for their being lifted quite out of the fluid and again immersed at pleasure. Each lantern was fitted with a somewhat small incandescent lamp, and when, upon pressing a button, the circuit was completed, the carbon filament enclosed instantly responded by emitting a powerful light. This light, while inferior to that produced by oxyhydrogen, was of sufficient intensity to serve every requirement in parlour demonstration; and although its exhibition partook of a tentative character, yet were the results of an exceedingly satisfactory nature.

ROYAL INSTITUTION.—At the general monthly meeting of the members, held on Monday, the following lecture arrangements were announced:—Six lectures (adapted to a juvenile auditory) by Prof. Dewar on "The Story of a Meteorite;" three lectures by Professor Ball on "The Astronomical Theory of the Great Ice Age;" three lectures by Mr. R. Stuart Poole on "Naucratis;" three lectures by Mr. C. T. Newton on "The Unexhibited Portion of the Greek and Roman Sculptures in the British Museum;" six lectures by Prof. Gamgee on "The Function of Circulation;" four lectures by Prof. Roberts-Austen on "Metals, as Affected by Small Quantities of Impurity;" four lectures by Prof. Boyd Dawkins on "The Ancient Geography of Britain;" four lectures by Prof. Tyndall on "Light;" four lectures by Mr. A. Geikie on "The History of Volcanic Action in the British Isles;" two lectures by the Rev. C. Taylor on "The History of Geometry;" two lectures by Mr. E. B. Poulton on "The Nature and Protective Use of Colour in Caterpillars;" two lectures by Mr. H. Grubb on "The Astronomical Telescope;" and two lectures by Prof. Oliver Lodge on "Fuel and Smoke."

A HIGH-SPEED ENGINE.—During the last year or two it has come to be generally understood that large machines, driven at a comparatively low speed, were the best for electric lighting purposes; but the lighting at the Lincoln's Inn Dining Hall and Library must be considered as an exception to this rule. The dynamo here is driven, at no less than 12,000 revolutions per minute, by a Parsons high-speed engine, which justifies its title by running at the same rate. It requires some mental effort to take a statement of this kind seriously; yet there is no reason to regard the Parsons motor as a toy. It was shown in action at the Inventions Exhibition, running with unimpaired steadiness from the commencement to the close of the show. It is, in reality, a combination of turbines driven by steam, and consists of two series of parallel flow turbines to the right and left of a central steam inlet; the steam exhausting directly from the first turbine into the second, from the second into the third, and so on through twenty turbines in each series. The steam parts with a portion of its energy in each turbine, and finally escapes at a pressure not much above that of the atmosphere. It is claimed that this is the first motor that has ever been made to work at the actual velocity of the steam as it escapes from the boiler.

THE WIRT BATTERY.—The Wirt cell is a modification of the Daniell. It is so constructed that the fluids cannot become disturbed or mixed through any slight jarring, and consists of three square bottles, 1¼ square inch by 4½in. high, with a neck ⅝in. in diameter by 1in. long, securely clamped together at the top and bottom. In the upper part of the adjoining sides of bottles I. and II. is drilled a small hole ⅜in. in diameter, and in the lower part of the adjoining sides of bottles II. and III. are similar holes, all arranged to correspond with each other. A soft rubber washer separates the bottles at the holes, making a water-tight joint, and also acting as a support to hold in place a thin film of goldbeater's skin, through which

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the liquids must pass, by the process of endosmose and exosmose, from one bottle to the other. All of the bottles are filled with a dilute solution of sulphate of zinc; within bottle I. is placed a piece of sulphate of copper about the size of a pea, which changes the solution to a blue colour; the copper electrode at the bottom is connected by an insulated wire, which passes through the cork. At the bottom of bottle II. is a small piece of zinc which collects any deposit of sulphate, should any pass through from bottle 1. In the top of bottle III. is suspended the zinc electrode, which measures about 1⅛in. long by ¾ wide and ⅛ thick. This arrangement is supposed to give a very constant battery which cannot polarise, as each electrode is completely isolated, and the separation of the bottles with the goldbeater's skin also prevents an easy mixture of the solutions.

Soudan Medals.—The medals awarded to the Grenadier Guards and the Army Postal and Telegraph Corps, attached to the 24th Middlesex (Post Office) Rifle Volunteers, for service in the late campaign in the Soudan were presented a few days ago to the officers, non-commissioned officers, and men entitled to the honour, on the parade ground of Wellington Barracks, in the presence of a full attendance of both regiments and a large number of spectators. The 3rd Battalion of Grenadier Guards, under the command of Colonel Thynne, C.B., and the Post Office Rifles, under Colonel Du Plat Taylor, were formed up in column, and, prior to the presentation, were addressed by Colonel Philip Smith, who, in a few appropriate words, congratulated first of all the Grenadiers on the opportunity which had been afforded them of serving their country in war and gaining distinctions denied to older soldiers. Addressing the detachment of volunteers, Colonel P. Smith expressed the gratification he felt in welcoming back Major Sturgeon and the non-commissioned officers and men who had formed part of the Postal and Telegraph Corps, and had rendered the State a most important and valuable service. There was nothing more benefiting to the soldier in time of war than prompt and correct telegrams and the anxiously anticipated letters from home, the duties with regard to which were so admirably carried out by the men who had volunteered, and throughout the campaign had performed in Her Majesty's service a most important duty. The medals were then distributed, after which the parade was dismissed.

Old Students' Association.—On Tuesday, the 1st inst., the second general meeting of the City and Guilds of London Finsbury Technical College Old Students' Association took place at the Finsbury College. The proceedings of this association (which has for its object the promotion of social intercourse among its members, and the encouragement of their interest in the welfare of the college) consisted of a presidential address by Mr. H. Newman Lawrence, a late student, and the reading of a paper on "Opacity," by Prof. Silvanus Thompson, B.A., D.Sc., the Principal of the College The President, in an interesting address, pointed out a few of the lines on which the attainment of the objects might be arrived at. He volunteered to keep a register of technically educated students requiring suitable employment, and of employers of scientific labour requiring assistants, &c.; he also proposed to establish a system of correspondence between members desiring to obtain and those willing to give information on special subjects; he also suggested that the usual monthly meetings should not only consist of the the hearing and discussing of technical papers, but should be varied with concerts and even dances, and thus produce real, social intercourse. He, in the finish of his address, said that he was quite confident that though the present association only consisted of about seventy members and had to borrow rooms for its meetings, it would in a short time have its own rooms, laboratories, and library, as well as a recognised position among the older scientific societies. Prof. Thompson, in his paper on "Opacity," dealt with the electro-magnetic theory of light, and exhibited his collection of tourmalines, the electrical and optical properties of which stones are well known. He also showed an artificial tourmaline of his own design, constructed of layers of glass and wire gauze, having all the electrical and optical properties of the real stone. The proceedings terminated with an announcement of a concert, to take place early in January.

The Telephone and the Opera.—There is some talk, says the *Daily News*, of a new telephonic enterprise which will far surpass all we have lately heard from Rheims. Wires are to be laid on at the Opera, and the music brought, not exactly into our houses, but into a public hall, where the passer-by may take a shillingsworth of Covent Garden just for curiosity. There is warrant for it; during the Electrical Exhibition in Paris the Palais de l'Industrie was connected with the Grand Opera in this way. A room was filled with telephonic ear trumpets, and the crowd was so great that every tube holder had to be limited to the short lease of ten minutes. Something was heard, and heard fairly well, when the orchestra was in full blast; but in the vocal parts all but the soprani came out a mere subterranean rumble. It was chronicled at the time as prima donna by telephone, and it served to make money, which will probably be the only purpose of any new scheme of the kind. Writing to a contemporary upon this subject, the general manager of the National Telephone Company says:—"It may be of interest to learn that the 'new' telephonic enterprise projected at Rheims has been an accomplished fact in Scotland for at least two years past. Subscribers to this company's Dundee, Broughty Ferry, Newport, Perth, Forfar, and Arbroath Exchanges are, on demand, switched on to the Dundee Theatre Royal while a performance is proceeding, and, by means of transmitters fixed near the orchestra, are enabled to hear the music, dialogue, applause, &c., in their own offices or homes. The privilege is very frequently taken advantage of. The general public are not excluded. Any person, by going to one of the company's call-offices in any of the above-named towns, and paying the usual small fee, may enjoy the distant performance equally with subscribers. This comprises all that is proposed to be done in France, so the claim to novelty is certainly (if not without Rheims) without reason. Similar arrangements could be made in Edinburgh, or any other town where the company possesses an exchange, if the subscribers wished and the theatre lessee were willing."

Secondary Battery Litigation.—The decision given some time ago by the Examiners-in-Chief of the United States Patent Office in the case of Sellon *v.* Hochhausen has been appealed against. The application of J. S. Sellon was filed July 14, 1883, and the application of W. Hochhausen on June 21, 1883. Haid, who was a third party to this interference, dropped out of the case, and was not a party to this appeal. The decision was as follows:—"In interference proceedings, where neither applicant files a preliminary statement, the senior applicant will, under Rule 111, be *presumed* the first inventor, and priority awarded him. In such cases where the invention in controversy is disclosed in the application of the senior applicant priority cannot be awarded the junior applicant, even though such senior applicant expressly disclaims, for the present, any claim to a patent for such disputed invention. In such interference cases priority must also be awarded such

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senior applicant, notwithstanding the oath of the junior applicant discloses the fact that he has received British patent for his invention which antedates the time of the filing of either application." In summing up the case the Commissioner of Patents said :—" It might be admitted for the purpose of this controversy that Sellon actually had an English patent which antedated the filing of Hochhausen's application, and it could make no difference with the award in this case. If it were admitted that Sellon's English patent issued and bore date three months anterior to the filing of Hochhauson's application, still that would come far short of proving that Sellon was the inventor of the thing which he patented in England. The issue of an English patent is by no means evidence that the patentee is the inventor, as in that country patents are issued not only to inventors but to importers of inventions. Independent of this, however, I have no hesitation in declaring that priority must be awarded upon this record to Hochhausen. The argument of counsel for Sellon was ingenious and exhaustive. Upon reflection, however, there is nothing else to do but to affirm the decision of the Board. It is perhaps to be regretted that a case of this kind should be permitted to go off upon such a question. If Sellon really has a meritorious claim to be regarded as the first inventor, it is to be regretted that he has not attempted to show it by his proof. It is sufficient for me, however, that he has not done so, and I must dispose of the case as it comes to me."

Small Installations in Somersetshire.—The large Reading Room of Horsington, Somersetshire, was lit up for three nights last week by ten Woodhouse and Rawson 20 candle-power lamps at a *conversazione* and exhibition held there, the current being obtained from a battery of accumulators 160 yards off, at the residence of the Rev. J. D. C. Wickham, and conducted by a bare copper cable hung on insulators, an iron water-pipe being used for the return lead. The lights were perfectly steady, and showed off the various exhibits, especially the pictures, to great advantage, besides being very convenient for the purposes of such an entertainment, owing to their capability of being lowered or put out as occasion required. Other uses of electricity were also exemplified by an arc lamp, used in a magic lantern, and supplied by a Griscom motor, which also worked a sewing machine ; by an induction coil, which illuminated vacuum tubes; by Edison's electric pen, which was exhibited during a short lecture upon his life by a gentleman present; and by a tone telephone, which conveyed music into the room from a distant and invisible source. This was kindly lent by Messrs. Paterson and Cooper, of London. The Rev. J. D C. Wickham, under whose directions the installation was put down, has lit his house completely with Swan 10 candle-power lamps for some time past. Accumulators supply the current, and have hitherto served him well, increasing rather than deteriorating in efficiency. He has two batteries, one of E.P.S. Co.'s cells, the other of Messrs. Elwell and Parker, capable of working independently when each lights a moiety of the lamps; or of being combined in series for charging, or when a higher E.M.F. is required, as, for instance, for experimental work. The main leads from the battery are carried to terminal screws upon a board in the hall, to which the branch wires are also led. The lamps have mostly their separate switches coated with luminous paint, so as to be easily found in the dark. Cardew's voltmeter and Ayrton and Perry's spring ammeter are used as measuring instruments, and are found very reliable. In spite of some difficulties, such as, for instance, the adjustment of the brushes of the dynamo, and the determination of the amount of charge in the accumulators, Mr. Wickham finds the work of domestic electric lighting fairly within the capabilities of an amateur, and though the first cost has been considerable, and the attention necessary rather irksome, this is made up for by the cheerfulness, beauty, and convenience of the light, and by the unfailing interest which the supervision of his small installation affords.

City and Guilds of London Institute.—At the quarterly meeting of the council the Earl of Selborne, chairman of the council, made an appeal to the City and Livery Companies of London to subscribe the necessary funds to complete the work of organising a national system of technical education, on the success of which, he said, the commercial prosperity of the country so greatly depended. He referred to the large sums of money which the companies had already contributed, but at the same time he compared the smallness of the whole amount asked for by the Institute with the total corporate income of the companies, and pointed out that by liberally subscribing the funds now needed, the City Guilds would deserve, and he hoped obtain, the permanent gratitude of the nation. On Wednesday night a presentation of prizes and certificates took place in the Salters' Hall, St. Swithin's-lane, City. The Lord Mayor presided, supported by Alderman Sir Robert N. Fowler, Bart, M.P. ; Mr. John Watney, Mr. Owen Roberts, honorary secretaries ; and Mr. Philip Magnus, director and secretary of the institute ; the masters of several of the livery companies, Profs. Armstrong, Ayrton, Henrici, Unwin (of the Central Institution), S. P. Thompson, Perry, Meldola, and Mr. Brophy, of Finsbury Technical College ; Mr. Sparkes, of the South London School of Technical Art ; Colonel Donelly, R.E., of the Science and Art Department ; Mr. L. L. Cohen, M.P.; Sir George Young, Bart. ; Captain Galton, Professor Leone Levi, and Sir Sherston Baker. The reports were read by Mr. John Watney and Mr. Owen Roberts (hon. secretaries), of the Central Institution, Exhibition road, South Kensington ; the Finsbury Technical College, and the South London School of Technical Act. These documents showed a general increase in the number of students under instruction. A report as to the technological classes stated that the total number of students in attendance at them was 6,396, as compared with 5,874 in the year previous ; and there were 7,600 students preparing for the examinations in May next, or 552 more than in the previous year. These numbers did not include those at the institute or technical colleges, nor students of university rank. Nothing, perhaps, better indicated the spread of the influence of the institute than the fact that at the present time there were 321 classes in 162 different centres in the United Kingdom. At intervals between the reports being read the successful students, amongst whom were not a few ladies, were presented with their prizes and certificates by Sir Robert N. Fowler, Bart, M.P. The following were the principal prize-takers :—The Albany Scholarships of £50, given by the Corporation of London in memory of the late Duke of Albany, won by A. E. Rossiter and M. H. Crompton ; the Siemens Memorial Scholarship of £50, founded by Lady Siemens in memory of the late Sir William Siemens, C. Priest; the Mitchell Scholarship of £30, given by the Mitchell Trustees, A. Chatterton and W. Heller; the Clothworkers' Company Exhibition of £60, tenable for a period of the full curriculum of three years, W. E. Sumpner. The foregoing relate to the Central Institution ; the following to the Finsbury College :—The Mitchell Scholarship, J. E. Kupli ; the Saddlers' students were W. B. Clarke, J. W. Jones, A. E. Richardson, and J. R. S. Court, and the Holl scholar was J. M. Smith. An address by Sir Robert Fowler, Bart., M.P., concluded the proceedings.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 47.)

[ERRATA IN LAST.—Line 25th, *for* three *read* six. Formula (111); multiply the left member by 4π. Also, cancel (112), and substitute

$$\left.\begin{aligned} 8\pi(\mathrm{U}-\mathrm{T}) &= \Sigma(\mathrm{E}c\mathrm{E}-\mathrm{H}\mu\mathrm{H}), \text{ through volume,} \\ &= \Sigma\mathrm{N}(\mathrm{VEH}'-\mathrm{VE'H}) \text{ over surface.} \end{aligned}\right\} \quad (112)$$

the accent denoting differentiation to n. Test by the convergence theorem.]

Remarks on Normal Electromagnetic Systems. Conditions of Possibility of Oscillatory Subsidence. Equal Roots, and their Effects.

In the last section I omitted to define the three symbols, U_{rr}, T_{rr}, and Q_{rr}, except by implication. They express the *doubles* of the potential energy, kinetic energy, and dissipativity of the rth normal system E_r, H_r; being quantities formed in the same manner as Q_{12}, U_{12}, and T_{12}, defined just after equation (105).

As a preparation for what follows it will be useful to bear in mind the general character of the subsidence to equilibrium of a displaced elastic body, which, for our purpose, may be simply a stretched elastic thin wire fixed at its ends. Let it be bent into the form of the arc of a bow, or, more accurately, into the form of the sinusoidal curve, and then be left to itself. If there be no resistance the wire will go on vibrating for ever with uniform frequency, always preserving the sinusoidal form. But if there be resistance to its motion, proportional at every moment to its speed, its amplitude of vibration will continuously decrease, although the frequency (lowered) will be still uniform. By a sufficient increase in the coefficient of resistance (say, by motion in a viscous fluid), we shall ultimately stop the vibrations, the displaced wire returning to, but never crossing its equilibrium position. The displacement at time t in the original frictionless vibration was represented by

$$(a_1 \sin + b_1 \cos)\, c_1 t.$$

Friction makes it

$$\epsilon^{-c_2 t}(a_2 \sin + b_2 \cos) c_3\, t,$$

showing the oscillatory subsidence to equilibrium. When, by sufficient increase of resistance, the oscillations are just stopped, it is

$$\epsilon^{-c_4 t}(a_3 + b_3 t)$$

and finally, further increase makes it

$$a_4 \epsilon^{-c_5 t} + b_4 \epsilon^{-c_6 t}$$

the sum of two independent non-oscillatory subsidences.

In general, if inertia be altogether negligible, but not elastic yielding, or the friction, there can be no oscillations. Similarly, if the elastic yielding be negligible, but not inertia and friction, there can be no oscillations. To have oscillations we require both inertia and elastic yielding; besides that the resistance must not be too great.

Coming now to the electro-magnetic applications, we shall expect the subsidence of normal systems to come under these four types. If there be no elastic displacement, and therefore no potential energy, the subsidence of a normal system must be non-oscillatory; and it must be real subsidence, not indefinite increase according to the same law. Similarly, if there be no inertia ($\mu = 0$, no magnetic induction, no magnetic or kinetic energy), the subsidence must also be real and non-oscillatory. But if neither elastic displacement nor inertia be negligible, there will be either non-oscillatory or oscillatory real subsidence, according to the relative importance of the resistance. In these three cases there is supposed to be always resistance. But if there be none, but only elasticity and inertia to consider, the normal systems will be simple harmonic with respect to the time, and go on vibrating for ever. Cases in which two of the three quantities c, k, and μ are non-existent, scarcely belong to the present subject. And the fourth case above (vibrations in dielectric media, with *no* dissipativity) does not occur in ordinary problems, as it requires unrealisable conditions.

Now, the equation of activity of a normal system is

$$2n(\mathrm{U}+\mathrm{T}) + \mathrm{Q} = 0,$$

where $\mathrm{U} = \Sigma\mathrm{E}c\mathrm{E}/8\pi$, $\mathrm{T} = \Sigma\mathrm{H}\mu\mathrm{H}/8\pi$, $\mathrm{Q} = \Sigma\mathrm{E}k\mathrm{E}$. Here E and H constitute a normal system, E being a solution of (110) and H derived from it by the second of (109); or else H being a solution of the H equation corresponding to (110), and E derived from it by the first of (109). [If there be no inertia, the electric force is polar. Then the single scalar, the electric potential, will serve for variable.]

If n be real, the normal functions E and H are real, or may be so chosen as to be real. Then also Q, U, and T are real. Further, it is necessary in the electro-magnetic applications that they cannot be negative. This is secured by the angle between a force and a flux being less than 90° at the most.

[$c = 0$.] First, ignore elastic displacement. Then $c = 0$, U is non-existent, and

$$2n\mathrm{T} + \mathrm{Q} = 0.$$

We see at once that if n be real, it must be negative. If then we show that it cannot be imaginary, we prove that all the n's are real and negative, when c vanishes, but not μ and k. Thus, if i stand for $(-1)^{\frac{1}{2}}$, let

$$n_1 = a + bi, \qquad n_2 = a - bi,$$

be a pair of imaginaries. They turn H into $\mathrm{L} + \mathrm{M}i$ and $\mathrm{L} - \mathrm{M}i$ respectively, and E into $\mathrm{L}_1 + \mathrm{M}_1 i$ and $\mathrm{L}_1 - \mathrm{M}_1 i$ respectively, L, M, &c., being real. Using n_1, the expressions for T and Q become

$$\left.\begin{aligned} \mathrm{T} &= \Sigma\,(\mathrm{L}\mu\mathrm{L} - \mathrm{M}\mu\mathrm{M} + 2i\mathrm{L}\mu\mathrm{M})/8\pi \\ \mathrm{Q} &= \Sigma\,(\mathrm{L}_1 k\mathrm{L}_1 - \mathrm{M}_1 k\mathrm{M}_1 + 2i\mathrm{L}_1 k\mathrm{M}_1) \end{aligned}\right\}$$

Using these in the equation of activity, with $n = n_1$, and separating the real from the imaginary parts, we get

$$0 = \Sigma\{2a(\mathrm{L}\mu\mathrm{L} - \mathrm{M}\mu\mathrm{M}) - 4b\mathrm{L}\mu\mathrm{M} + 8\pi(\mathrm{L}_1 k\mathrm{L}_1 - \mathrm{M}_1 k\mathrm{M}_1)\}$$
$$0 = \Sigma\{2b(\mathrm{L}\mu\mathrm{L} - \mathrm{M}\mu\mathrm{M}) + 4a\mathrm{L}\mu\mathrm{M} + 16\pi\mathrm{L}_1\mu\mathrm{M}_1\}$$

But also, by the conjugate properties in $(108)_1$, we have the mutual T and Q of the two systems n_1 and n_2 both zero;

or $\qquad \Sigma(\mathrm{L}\mu\mathrm{L} - \mathrm{M}\mu\mathrm{M}) = 0, \qquad \Sigma(\mathrm{L}_1 k\mathrm{L}_1 - \mathrm{M}_1 k\mathrm{M}_1) = 0$;

the imaginary parts cancelling. These bring the previous equations to

$$b\Sigma\mathrm{L}\mu\mathrm{M} = 0, \qquad a\Sigma\mathrm{L}\mu\mathrm{M}/4\pi + \Sigma\mathrm{L}_1\mu\mathrm{M}_1 = 0.$$

From the first of these we conclude that $b = 0$, unless L and M are the magnetic forces of two normal systems, which is not the case here. The imaginary parts are therefore non-existent, which brings us to

$$n_1 = a, \qquad n_2 = a, \qquad \mathrm{T} = 0, \qquad \mathrm{Q} = 0.$$

What we wanted to show was that imaginaries could not exist. In addition, we show that if there be a pair of *equal* n's, they will make the kinetic energy and the dissipativity of the (equal) normal systems both zero. The only way this can happen, T and Q being the sum of quantities that cannot be negative, is for each of their elements to vanish, and, therefore, $\mathrm{E} = 0$, $\mathrm{H} = 0$. That is, if n be double (or repeated any number of times), that value of n will make the normal functions vanish over all space.

[$\mu = 0$.] Next, ignore magnetic induction. Then $\mu = 0$, T is non-existent, and

$$2n\mathrm{U} + \mathrm{Q} = 0.$$

We can show that the n's are all real and negative, excluding oscillatory subsidence, and that the first conditions of a repeated n are

$$\mathrm{U} = 0, \qquad \mathrm{Q} = 0.$$

which necessitate the vanishing of the normal functions for that value of n. But, owing to the peculiarities arising from the division of space into conducting and non-conducting regions, the matter cannot be shortly treated, and will be returned to.

[c, k and μ.] Take next the general case of T, U, and Q all existent. Write the activity equation thus,

$$2n^2(\mathrm{U}+\mathrm{T}) + n\mathrm{Q} = 0,$$

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and solve as a quadratic. Then,

$$n = \{-Q \pm (Q^2 - 4n^2UT)^{\frac{1}{2}}\}/4U,$$
$$n = \{-Q \mp (Q^2 - 4n^2UT)^{\frac{1}{2}}\}/4T,$$

Remembering that if n is real, Q, U, and T are all positive (if not zero), we see that $Q^2 > 4n^2UT$, or $Q^2 > \dot{U}\dot{T}$, or the dissipativity greater than the geometrical mean of the rates of decrease of the potential and kinetic energies, must be true. And n is negative. The limit of reality is reached when $Q^2 = 4n^2UT$; or

$$U = T, \qquad 4nU + Q = 0, \qquad 4nT + Q = 0.$$

Thus $U_{12} = T_{12}$, the general conjugate property of two normal systems (n_1 and n_2) when they are unequal, is also true when they are equal, *i e.*, when n is a double root of the determinantal equation of n. This includes the previous special cases of either $c = 0$, or else $\mu = 0$. Further information regarding imaginary n's may be obtained by separating the real from the imaginary parts in the above.

[$k = 0$.] When we take $k = 0$, in the equation of the normal E functions, we have

$$\text{curl}.\mu^{-1}\text{curl}.E + cn^2E = 0; \quad \mu nH = -\text{curl}.E; \quad . \quad . \quad . \quad (113).$$

If, on the other hand, we take $c = 0$, we have an equation for E of the same form, but containing n instead of n^2. Hence the same normal functions serve in both cases, if $4\pi kn$ and cn^2 be exchanged. Former conclusions regarding n in the case $c = 0$ are therefore now true of n^2. That is, every n^2 is real and negative, making the n's pairs of oppositely signed equal imaginaries, as

$$n_1 = ai, \; n_2 = -ai; \; n_3 = bi; \; n_4 = -bi; \; \&c. \quad . \quad . \quad . \quad (114).$$

where a, b, &c., are real, indicating simple harmonic oscillations without subsidence.

The property $U_{12} = T_{12}$ is true for any two roots, whether naturally associated or not; *i.e.*, for n_1 with respect to all the rest, including its companion n_2, whose square is the same. But also, the second and third conjugate properties (106), keeping in the $(n_1 - n_2)$ factor there omitted, are

$$(n_1^2 - n_2^2)U_{12} = 0; \qquad (n_1^2 - n_2^2)T_{12} = 0;$$

hence $U_{12} = 0 = T_{12}$, except if $n_1^2 = n_2^2$; that is, in case of the naturally paired n's. Also, the equation of activity becomes

$$U + T = 0,$$

for every single root n.

As the first of (113) contains n^2, if we take the E normal functions from it, they will be identical in pairs, $E_1 = E_2$, $E_3 = E_4$, &c., for the roots (114).

But then the second equation (113) shows that the corresponding H functions are the negatives of one another in pairs, thus $H_1 = -H_2$, $H_3 = -H_4$, &c. Thus the expansions of E_0 and H_0, the initial states of electric and magnetic force, become

$$E_0 = (A_1 + A_2)E_1 + (A_3 + A_4)E_3 + . \; . \; . \; ,$$
$$H_0 = (A_1 - A_2)H_1 + (A_3 - A_4)H_3 + \; . \; . \; . \; .$$

The mutual potential energy of any two double normal systems is zero, and the same is true of the mutual kinetic energy. We therefore have

$$\Sigma E_0cE_1 = (A_1 + A_2)\Sigma E_1cE_1,$$
$$\Sigma H_0\mu H_1 = (A_1 - A_2)\Sigma H_1\mu H_1;$$

giving A_1 and A_2 in terms of the initial state E_0, H_0. Using these, and putting the solutions in the appropriate real form, taking $H_1i = M_1$, $H_3i = M_3$, &c, we find that

$$\left.\begin{aligned} E_0 &= \frac{E_1}{\Sigma E_1cE_1}(\Sigma E_0cE_1 . \cos - \Sigma H_0\mu M_1 . \sin)\,at + . \; . \; . \\ H_0 &= \frac{M_1}{\Sigma E_1cE_1}(\Sigma E_0cE_1 . \sin + \Sigma H_0\mu M_1 . \cos)\,at + . \; . \end{aligned}\right\}$$

express the values of E_0 and H_0 at time t later.

The proof that there cannot be any imaginary n^2's requires some modification from the proof of absence of imaginary n's in the case $c = 0$, owing to the changed conjugate properties. It also shows that a repeated n^2 makes the normal functions vanish. [*See* Thomson and Tait on "Cycloidal Motion with no Dissipative Forces.]

[Equal roots.] This remarkable property of the vanishing (with equal roots) of the normal functions in case any one of the three c, k, and μ is zero, is closely connected with another property, viz., that of shutting out the $t\epsilon^{nt}$ term from the solutions. Looking to the formulæ at the commencement of this section, we see that on the boundary between oscillatory and non-oscillatory subsidence we have, instead of the form $a_1\epsilon^{n_1t} + a_2\epsilon^{n_2t}$, that of $(a + bt)\,\epsilon^{nt}$. Also, when by a change in the value of some constant, two roots are made to approach one another, and then again diverge imaginary, between the two states we have a pair of equal roots. If, then, the oscillatory form of solution is possible we have the $t\epsilon^{nt}$ term on the very verge of oscillation. Now, in certain cases we know that oscillations are impossible; they require there to be both kinetic and potential energy concerned; so, if either be absent something must happen to prevent solutions taking the oscillatory form. That something is the vanishing of the normal functions, excluding the $t\epsilon^{nt}$ terms, and making the solution in case of a double root take the form $a\epsilon^{nt}$, the same as if the root were not repeated.

Let n_1 and n_2 be a pair of n's, and write down the corresponding terms of the E_0 expansion. They are

$$\frac{\Sigma(E_0cE_1 - H_0\mu H_1)}{\Sigma(E_1cE_1 - H_1\mu H_1)}E_1\epsilon^{n_1t} + \frac{\Sigma(E_0cE_2 - H_0\mu H_2)}{\Sigma(E_2cE_2 - H_2\mu H_2)}E_2\epsilon^{n_2t}. \; . \; . \; (115)$$

Here there are no restrictions put upon c, k and μ; E_1, H_1, and E_2, H_2, are the normal functions corresponding to n_1 and n_2, and the $U_{12} = T_{12}$ formula has been employed to find A_1 and A_2, the coefficients of E_1 and E_2 (the fractions).

At first glance it might appear that if, by some change in the value of some electrical constant concerned, or generally, by a changed distribution of c, k, μ, the roots n_1 and n_2 are made to approach and finally reach equality, making E_1 and H_1 also approach to and finally be the same as E_2 and H_2, their coefficients A_1 and A_2 will also approach and ultimately be equal. But, in general, nothing could be further from the truth, and instead of equality, we shall have infinite inequality, on account of the denominators approaching zero from opposite sides, sending one A up to positive and the other down to negative infinity. For if $n_1 = n + h$, and $n_2 = n - h$, where h is very small, we shall have

$$E_1 = E + hE', \qquad H_1 = H + hH',$$
$$E_2 = E - hE', \qquad H_2 = H - hH',$$

if the accent denote differentiation to n, provided the functions E, H, and their differential coefficients do not vanish. These make

$$\Sigma(E_1cE_1 - H_1\mu H_1) = 2h\Sigma(EcE' - H\mu H').$$

This is the value of the denominator of A_1 in (115), and that of A_2 is the same taken negatively, thus showing the infinite divergence of the A's.

The two terms, when united, and h made to vanish, give rise to a solution of the form

$$C_1F\epsilon^{nt} + C_2Et\epsilon^{nt},$$

where C_1 and C_2 are new constants, E is the old E, and F is a new function derived from E. From this we see that when the repeated n makes the normal functions vanish, as when any one of c, k, μ is zero, the second term goes out altogether.

The double root solution in these cases of vanishing E and H is

$$\frac{\Sigma(E_0cE' - H_0\mu H')}{\Sigma(E'cE' - H'\mu H')}E'\epsilon^{nt}, \quad . \quad . \quad . \quad . \quad (116)$$

differing from the original form only in this, that instead of the normal functions E and H we take their differential coefficients with respect to n. This single term takes the place of the former two terms.

If the root n be triple, E' and H' will also vanish. Then take E'' and H'' instead; and similarly go on to further differentiations in case of further repetitions of n.

If $N = 0$ be the determinantal equation of the n's, the function $U - T$ of a normal system contains N', the differential coefficient of N with respect to n, as a factor. $N' = 0$, in addition to $N = 0$, is the condition that n is a double root. Similarly, the function $U - T$, not of E and H, but of E' and

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H′, contains N″, the second differential coefficient of N, as a factor, and so on.

Before leaving this curious subject of the effect of equal rates of subsidence, we should notice that when the duplicity of an n, making the conjugate properties of unequal n's hold good for two of the same value, necessitates the simultaneous vanishing of the normal functions, it does so in virtue of the positivity of Q, U, T, as before mentioned. But should they be allowed to be negative, although, for example, in the case $c=0$, we still have $T=0$, $Q=0$, when an n is double, there is no longer any necessity for E and H to simultaneously vanish. Then we have the $t\epsilon^{nt}$ term, and the $t^2\epsilon^{nt}$ term if a triple root, and so on. The vanishing of T will then depend on its expression containing N, for the special value of n, as a factor. As our expressions for Q, U, and T are in the form of the sum of scalar products, we can only make any one of them negative by allowing that the force and the flux, in some parts of space at least, can make an obtuse angle with one another; that is, be opposed, which is a contradiction to common sense. In special applications, involving only a limited number of degrees of freedom, the positivity of U, T, and Q will require that certain functions of the electrical constants, usually determinants, cannot be negative for any values of the electric variables.

(To be continued.)

THE MANUFACTURE OF THE CRUTO INCANDESCENT LAMP.*

The well-known and frequently-described Cruto lamp has attracted attention at exhibitions at Munich, Vienna, Turin, and Paris. According to published measurements made, the energy absorbed in these lamps is 3·4 volt-amperes per standard candle. The process of making the carbons may be described:—(1) Formation of the carbon filament. (2) The fitting of the latter to the platinum. (3) Sealing into the globe. (4) Exhaustion of the lamp. (5) Testing the finished lamp. (6) Accessory fittings.

In the case of the Cruto lamp carbon, which is obtained by a deposition of carbon on platinum after the manner of Wollaston's process, the employment of furnaces and moulds is unnecessary, and the resistance of the filament can be easily regulated during the course of manufacture.

The apparatus used for the depositing is simply a long glass vessel filled with a gaseous hydro-carbon, in which is suspended a platinum wire maintained at a dull heat by means of a current of electricity. By contact with the heated wire the gas is decomposed, producing a deposit of carbon upon it. The layers of carbon so obtained now take part in the incandescence, producing a further decomposition, and thus rendering the process continuous.

The gas generally used for the operation is ethylene (C_2H_4), generated in large receivers from a mixture of one part of ethylenic alcohol and two of pure sulphuric acid. Before the gas is allowed to enter the gasometer it is washed several times with pure water, or water containing calcium chloride and sulphuric acid, in order to purify it from the different compounds formed simultaneously with itself, such as ether, carbon dioxide, sulphuric acid, &c. On leaving the gasometer the gas is further dried with calcium chloride and Nordhausen sulphuric acid.

The platinum wire itself is made by the Wollaston process. A metal wire is drawn out to a very small sectional area, and then coated with silver. The wire is then drawn still further till its whole diameter is $\frac{1}{40}$th of a millimetre, and that of the platinum alone $\frac{1}{100}$th of a millimetre.

In the Cruto lamp the length of wire depends on the type of lamp required. The wire is bent into the shape of a U, while its extremities are firmly held in clamps. The silver is dissolved with dilute nitric acid, and the wire suspended in the apparatus.

These different operations are conducted by women, who do their work well and accurately.

* From *Zeitschrift für Electrotechnik.*

All the carbon depositing vessels are connected in parallel with the terminals of a Gramme machine in series with a semicircular rheostat of 200 ohms, subdivided in portions of 10 ohms each, with an additional resistance of 30 ohms, composed of two groups of 5 ohms, five of 2, and ten of 1.

The resistance of the filament is so high that an electromotive force of 180 volts only gives a weak current. However, in order still further to reduce the current, a movable arm can be used as a shunt. The long glass vessels already mentioned are arranged in two rows on either side of the table, all connected by a central wire with the positive pole of the machine. The current passes from this wire through the rheostat, then through the glass vessels, and then through a switch back to the negative terminal. Shunt circuits are brought into use by two wires joining the negative pole of the dynamo with all the movable arms.

If we follow the change of resistance in the wire, and construct a curve representing its values at intervals of 10 ohms, we find that the resistance of the platinum wire at first decreases, and then rapidly reaches a value higher than that with which it started. An explanation suggested is that the platinum wire melts at a particular moment, and leaves the carbon alone, or that a *quasi* compound of platinum and carbon is formed. After this the resistance steadily falls, while the curve becomes more regular. In order to prevent interruption of the decomposition of the gas, the wire must be maintained at a high temperature. At the commencement of the operation a very small current is sufficient for this purpose. The rheostat, which admits of any necessary variation, allows the current from the dynamo to be reduced to the amount required. The resistances being so adjusted as to maintain the filament at a constant temperature, the strength of current passing through the wire is gradually increased as it grows in thickness. A simple contrivance, due to M. Thibaudeau, allows the resistance of the filament used to be gradually adjusted with sufficient accuracy, the operation being stopped when the necessary value has been obtained.

A special arrangement insures that the measurement is taken with the filament at a constant temperature. The standard resistance of the apparatus, equal to that of a sample filament in course of construction, is fixed, once for all, in a Wheatstone bridge. The operator has only to press a key to see whether the corresponding filament is finished or not—that is to say, whether its resistance has reached the necessary value.

At the commencement of their formation the passage of a current through such fine and flexible conductors puts them under the influence of the magnetic action of the earth. They must therefore be placed on a plane at right angles to the needle of an inclination compass in the magnetic meridian. The support of the apparatus is therefore made movable to admit of adjustment in any desired position. But besides this magnetic action there is the mutual repulsion of two parallel currents flowing in opposite directions, tending to separate the two halves of the loop. The horseshoe begins to bulge, and the wire will acquire a clumsy appearance if care is not taken, as soon as the filament begins to get solid, to reverse the direction of the current by a suitable switch. The wire then shows a tendency to take a spiral form, the two portions of the loop draw together, and the horseshoe form is obtained. The current is now restored to its original direction. If the change is made too suddenly the wire twists into the shape of an 8 with its upper half broken—thus, 8. The bending over of the upper part and the excessive strength of the current destroy the wire at the instant when the two loops come in contact with each other. With the aid of a magnet it is easy to move a filament in various ways, and this method is employed in practice to correct distortions which have occurred in the process of manufacture.

The action which takes place in the process of deposition of the carbon is, from a chemical point of view, somewhat difficult to explain. It can, however, be modified by the presence of gaseous compounds of alcohol or ether, in which case water also makes its appearance; care is therefore taken to remove these bodies by washing the gas. As regards the decomposition of the pure gas, there is nothing to go by except the works of Berthelot, who, however, has not published a

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complete explanation of the reaction. It may, however, be observed that the apparatus used for the manufacture of the filament could be advantageously applied to the study of the decomposition of ethylene. If the deposit takes place gradually, and with uniformity, the result is a correspondingly compact whole. If, however, from one cause or another this fails to happen, the wire appears as though composed of a number of tubes one within the other. The filaments are then useless, as they either break or scale off at the first passage of the current. But such accidents rarely occur in practice. The production of the carbon filaments by electro-chemical deposition of carbon occupies on an average about two hours and a half.

When the carbon filaments are equal in length and resistance they are of the same thickness. This is claimed as a great advancement on other methods of manufacture in which these three values, length, sectional area, and resistance are not so easily regulated. The filament has to be fixed to the extremity of the platinum wires fused into the glass as contacts. These platinum wires are made tubular at their ends, and the filaments are fixed into the tubes so formed by a deposit of carbon. The filament, fixed in a holder of the shape of an inverted U, is held in position by clamps. On the same surface, but separately insulated, the two tubular ends of platinum are held by a second pair of clamps. Between the four clamps the deposit is formed.

This method may be safely preferred to all methods now in use, even to the copper depositing process, and that of mounting with porous carbon points.

This part of the process relating to blowing the bulb and inserting the carbon calls for no special mention, differing little from the method adopted with other lamps.

The most difficult operation in the manufacture of the incandescent lamp is the exhaustion of the air. This is effected by means of a Sprengel pump, the general arrangement of which is well known. The branch tube by which the exhaustion is conducted has an enlargement on its upper portion containing some active hygroscopic substance such as sulphuric acid or phosphoric anhydride. The lamp to be exhausted is attached to a tube sealed into this enlargement. The completion of the exhaustion is indicated by the dull, unmusical fall of the drops of mercury in the pump. The filament of the lamp to be exhausted is connected in series with a rheostat in the circuit of a dynamo; when the globe is sufficiently exhausted, a current, weak at first, is allowed to pass, causing a far more rapid evolution of the rarefied gases, the mercury often falling quite silently. The current is gradually brought up to the normal strength used in the ordinary work of the lamp, and cut off as soon as the mercury appears to carry no more bubbles down with it. The lamp is then sealed up, and is ready for testing.

The management of the Sprengel pump requires excessive care. The mercury, for instance, must be dry and free from impurities. It is also necessary to keep it always pure. For this purpose it is washed with sulphuric acid, and passed before entering the pump through an atmosphere dried with calcium chloride, and a second bath of sulphuric acid. The lamps are also dried before being attached to the pump by a current of perfectly dry air.

Testing the Finished Lamp.—The finished lamps are brought into the test room to have their candle-power and efficiency tested by the eye, careful precautions being observed which allow of these operations being conducted with speed and accuracy. The amount of current used in a standard lamp of the same illuminating power is noted down on the lamp under test, which is then replaced by another. The same is done with the electromotive force. This classification is carried out very rapidly, and requires on the part of the operator only practice in observation. When greater accuracy of measurement is desired, the Bunsen photometer is observed simultaneously by two persons on opposite sides, and instruments, such as voltmeters and ammeters are used. In this case the photometric observations are repeated with a photometer with two screens. In this way the difference in tint of the two light spots thus placed side by side may be more easily estimated. These two methods, which are easily carried out simultaneously, are thus made to check each other. Besides these electrical and photometric measurements, further observations are made to determine the life of the lamp under normal conditions of use. The lamps are connected to a dynamo machine, with a single rheostat for each lamp, and another for the total current. A special contrivance allows the energy consumed by each lamp to be frequently increased without interrupting the current. In this way the changes in the resistance of the filament can be easily followed, and compared with the illuminating power obtained. A numerical result is thus reached for the best working conditions for the lamp.

Mounting the Lamp.—The mounting of the Cruto lamp calls for no special mention. All known systems have their good and bad points, and the method here adopted is certainly one

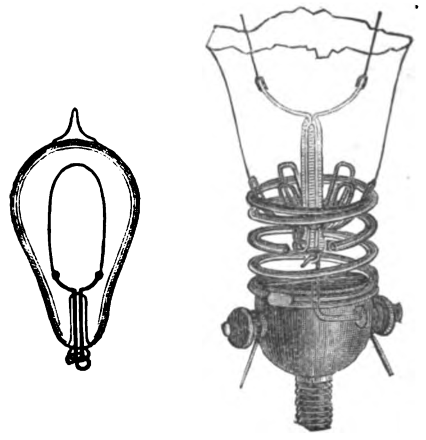

Fig. 1.

of the best (Fig. 1). The numerical constants of the different types of lamps are given below.

Type.	Candle-power.	E.M.F. in volts.	Current in amperes.
—	32	100	1·05
*A	20	100	·60
B	10	50	·60
C	16	50	1·05
D	8	25	1·05
E	50	50	2·30
*F	100	90	2·25

* These are double carbon lamps.

Small lamps of four to 20 volts are also manufactured for use with batteries, and are so efficient as to yield more than one candle per volt of electromotive force.

A Standard Cell.—M. Gaiffe remarked, as long ago as 1862, that the strength of the solution in chloride of silver batteries influenced their electromotive force, a stronger solution giving a smaller electromotive force. Upon this principle he has constructed a cell with a solution containing 5 per cent. of chloride of zinc, which gives an electromotive force of 1·02 B.A. volts, or 1·01 C.G.S. volts. It is necessary to employ pure materials, in order to keep the electromotive force of the standard cell constant. The temperature ought also to be kept constant during the time of observation, and to be the same degree in the various observations. Working with well-amalgamated zinc, pure melted chloride of silver, limpid solutions of pure chloride of zinc as neutral as possible and at the temperature of 18 deg. C., M. Gaiffe finds that the same solution always gives the same electromotive force. The liquor marked 107 by the densimetre appears to give the legal volt. In using the cell, resistances of at least 5,000 ohms should be used to prevent polarisation, as in the case of the ordinary chloride of silver element.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XV.

Volume XV. of "The Electrician," price 10s. 6d., is now ready. Also cases for binding, price 2s.

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THE ROYAL SOCIETY AND PROF. HUGHES.

Not long after the discovery of the microphone, the Royal Society publicly recognised the value of Prof. Hughes's achievement by electing him a member of that distinguished body. More than seven years have elapsed since that discovery, and in the interval Prof. Hughes has added many claims to the gratitude of the scientific world by his unceasing industry in a field of electrical and magnetic research which, until he entered upon it, was extremely obscure, but which is now, thanks to him alone, becoming clearer and more intelligible every day. In recognition of these further obligations the Royal Society has this year conferred upon him the Royal Medal; and we are glad to notice that in another quarter Prof. Hughes's claims have been acknowledged in the highest manner practicable, the Society of Telegraph-Engineers and Electricians having elected him President for the ensuing year. Honours such as these, besides reflecting credit on those who bestow them, are always welcome even to the most modest of men; and in the present instance, if we may say so without impertinence, they are probably accepted with especial gratitude, seeing that they are virtually the only kind of reward the recipient has sought or obtained for his labours. In the very first number of *The Electrician*, where the preliminary experiments of the microphone were described in some detail, it was stated that "Prof. Hughes has declined to patent his inventions, but gives them, with whatever value they possess, to the world;" and we believe he has followed this magnanimous rule in respect to his subsequent inventions in the same field of discovery.

Considering the enormous sums of money that have been made, and will continue to be made, by the adaptation of the microphone to telephonic purposes, if any man may be pardoned for regretting a generous impulse that man is Prof. Hughes. We do not assert that but for his discovery the magneto telephone of Graham Bell would have been greatly restricted in its area of usefulness. It is possible that the ingenious contrivances of Edison, which came very near to Hughes's discovery both in time and character, might have ultimately given to the telephone the powers it needed as a practical appliance for public use; but, as a fact, Hughes's inventions were not only first but best, though not designed with the special object of serving the telephone; and to this day, amongst numberless competitors, nothing has yet supplanted the simple microphonic arrangement which Prof. Hughes originally erected with the help of the telephone. Without the telephone of Prof. Graham Bell microphonic phenomena never would have been studied; without the aid of the English microphone the American invention might have been impaired in usefulness or greatly delayed in its general application. Money has been made with the patented instrument, and vast fortunes reaped from both instruments in combination, but none, that we ever heard of, with the unpatented instrument alone.

It has long been a complaint against the telephone that it is not serviceable for long distances; but with characteristic forgetfulness the public have lost sight of the fact that the distances which the telephone now traverses, and which are now very considerable, we owe entirely to the microphone. Magnetic variations obtainable from the telephone, with or without battery power, are so slight that, though excellent as far as they go, they go a very little way. With the help of microphonic combinations this drawback has been considerably abated already, and if the problem of long distance telephony is to be solved it will probably be in the same direction. The sound actually given off by the best of telephonic combinations is but the faintest fraction of the originating sound. It is audible, and it seems as loud, or nearly as loud, at the end of the journey as at the beginning, because it is confined within a small space and brought close to the ear. That the diaphragm reproduces sounds with fidelity in such minute facsimile is, perhaps, the most wonderful feature of the string telephone, as well as of the magneto telephone; but the sound is not the same sound either in its nature or volume, any more than the magnified image of some remote star as revealed by the telescope is the star itself. The daily newspapers in discussing the prospects and shortcomings of the telephone are, of course, all abroad on these nice points; but not the newspapers alone. Some attempts that have been made to accomplish long distance telephony in quarters that ought to have known better betray almost equal ignorance of the true nature of the difficulties to be overcome.

Perhaps the most hopeful direction in which to look for a removal of these difficulties is one of which we were again reminded in Prof. Hughes's speech before the Royal Society last Monday week. "A loose electrical contact will repeat in sound any variation of current passing through it; consequently, we may speak to one loose contact and listen to a second, when every word spoken to the first will be clearly heard." This is only a repetition of what was stated seven years

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ago, and verified many times since then. Telephones made of loose contacts for receiving as well as transmitting have been patented in considerable numbers; but generally, we believe, with the object of avoiding the patent rights of the magneto-telephone. If the same amount of ingenuity had been spent upon increasing the power of the transmitter and enlarging the mechanical effects on the receiver, telephony over longer distances than can at present be accomplished might have been practicable. But be this as it may, Prof. Hughes's microphone has already achieved a fame that will be immortal. His subsequent inventions arising out of it, the Induction Balance and Electric Sonometer, have a future before them hardly less important in the sphere of experimental and applied science; and the curious light which by their means already he himself has thrown upon magnetic phenomena promises to illuminate one of the darkest corners of natural physics. Talents such as those which invented the Type Printing Telegraph and discovered the Microphone are seldom combined in one person; and learned Societies may rejoice when so fitting an object can be found for the honours which are annually at their disposal.

CORRESPONDENCE.

THE INDIAN TELEGRAPH SERVICE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We beg to thank you most sincerely for the very able article in your issue of the 9th ult., in which you notice the grievances of the officers of the Indian Telegraph Department, and accord a body of hardly dealt with public servants your powerful support.

With regard to the third paragraph of the article, in which you specify two weak points in our memorandum, we would submit the following remarks:—

1. The memorandum, which was originally dated 1st April, 1885, was drawn up for private circulation amongst members of the department and their influential friends, and as there was no chance of them attaching the idea of "unseemly asperity" to any part of it, words here and there are doubtless not so carefully chosen as they would have been, had it been necessary to guard against the possibility of misconstruction. That it was thoroughly understood that no attack on the interests of "the men who create the block" was intended is proved by the fact that they have nearly all cordially joined the movement.

2. The subsequent more extensive circulation of the memorandum was an afterthought. We hoped to get it circulated before the close of the last Parliamentary Session, and, being pressed for time, we did not think it necessary to re-write it, for it never occurred to us that phrases perfectly intelligible to the original small circle of readers might be misconstrued by readers unacquainted with the fact that there is no antagonism whatever between the men appointed prior to 1868 and those more recently appointed.

3. We may be guilty of "special pleading," for we are pleading our own cause, and, such being the case, it is almost impossible we should not lay ourselves open in some respect to the charge, though we honestly believe we have exaggerated nothing.

4. The memorandum does not propose either compulsory retirements, or compulsory transfers, and we have good ground for believing that, if fairly generous terms are offered, there will be sufficient voluntary retirements to relieve the block in promotion.

5. We fully realise that to retire seniors only would be to shift the block, not to remove it; we therefore urge that inducements to retire be offered to all men of over 15 years' service in India, and we know that if reasonable inducements are held out the voluntary retirements will not be confined to seniors.

The suggestion to remove the block in promotion by increasing the number of appointments, is not likely to find acceptance with the Government of India, whose proposals for the reorganisation of the Departments provide for a decrease in the "superior" establishment (salaries Rs.250 to Rs.3,000 per mens), and a corresponding increase in the "upper subordinate" establishment (salaries Rs.250 to Rs.350 per mens).

This also is a change quite in accordance with the views of the executive officers of the Departments, who believe that from 25 to 30 of themselves may safely be retired without any need for filling the vacancies thus created, provided the number of "upper subordinates" be increased, and work be more equally distributed than it is at present.—Yours, &c.,

HONORARY SECRETARY (Indian) Telegraph
Engineers' Defence Committee.

Calcutta, 16th Nov., 1885.

HIGH-SPEED ENGINES AT THE INVENTORIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to a letter from a "Puzzled Student"—who seems to be very easily puzzled—the explanation he requires is as follows:—The machine described in detail in *The Engineer* of June 26th was one of two machines sent to Buckingham Palace, which, on test, gave 110 volts at 440 revs., whereas the machines doing the work at the Inventories, although of practically the same design, were of smaller dimensions, and were differently wound. They were designed to meet the Admiralty requirements of 80 volts at 400 revs., but, when tested at our works, they gave 80 volts at 370 revs., or 30 revs. below the specified speed. For the lighting of Old London, however, it was necessary to supply an E.M.F. of 120 volts at the terminals of the machines, and your "Student" will readily see for himself that the increased speed of 550 revs. was necessary to obtain these volts.

The mistake made by the writer in *The Engineer* is a very small one. He has simply given the dimensions of the Buckingham Palace machine twice over, instead of in the first instance describing the machine actually exhibited. No doubt the reason of this was that we supplied full and complete drawings as well as a photograph of the Buckingham Palace machine, whereas we were not able to supply detailed particulars of the machines exhibited. At any rate, we did not think such a slight error required correction. We quite agree with your correspondent that manufacturers of dynamos are proud of their slow-speeds, and probably we ourselves have gone as far in this direction as any one. Our letter, however, was not to enlarge on slow speed dynamos, but to call attention to the fact that thoroughly trustworthy, economical engines could be obtained to run at what we consider the high speed of 550 revs. per minute.—Yours, &c.,

R. E. CROMPTON AND CO.

Mansion House-buildings, London, E.C.,
December 1, 1885.

THE RECENT INCANDESCENT LAMP TESTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It was not our intention to take any notice of the published results of the Franklin Institute tests on incandescent lamps, as, considering the very strong comments that had been made on the subject in the various electrical papers, we thought it most unlikely that any one would be misled by them. We have, however, been advised that unscrupulous persons—more especially on the Continent—have been taking advantage of these tests to disparage our lamps. We shall therefore be glad if you will allow us the opportunity of emphatically denying that any reliance is to be placed in them, and of placing the following facts before your readers.

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We were advised by our agent in America to have nothing to do with the tests, as they would not be reliable, the Swan, Maxim, and other makers of incandescent lamps having refused to allow their lamps to be entered. We therefore decided not to compete. Lamps, however, stated to be ours were entered without our knowledge or consent, half being actually supplied by the Edison Company, the chief competitors, and the rest being obtained from another electric lighting firm. Whilst being admittedly run at five volts above what they were labelled, giving out up to 40 per cent. or 50 per cent. above the proper candle-power, they were placed in competition with lamps evidently most carefully made and tested beforehand.

As an example of the way in which the electrical press have treated the tests, we may call attention to the *Electrical Review* of America, dated June 13th, in which are given verbatim reports of interviews with the president and secretary of the Institute, the latter stating that he refused to have anything to do with the incandescent lamp tests, because he did not believe in them. Another official of the Institute stated some three months ago that it was very doubtful if the tests could be seen by outsiders, as the tests themselves did not agree.

Whilst in many instances disagreeing with the methods adopted in the actual tests, we refrain from criticising them, as we are well aware of the many difficulties that have to be contended with. We merely add that we think that the Institute ought to have seen that we were properly protected and advised of what was going on.

We are glad to hear that there is some chance of complete tests being made in this country, when every precaution will be taken to ensure their being properly made.—Yours, &c.,

WOODHOUSE AND RAWSON.

ELECTRIC HAULAGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have noticed in your issue of December 4th a letter, signed "H. S.," which is conspicuous for the spirit of carping criticism shown throughout. It is a well-known fact that immediately an inventor steps out of the beaten track to accomplish something which has proved a failure in other hands, there are plenty of so-called scientists ready with a perfect avalanche of figures to hurl upon his invention, and effect its total demolition. Such logicians of the schools, however, prove, day by day, that it is easier to demolish than to erect, and if by any chance they ever attempt a practical test of their own figures, they find to their cost how fallacious are their arguments. "H. S." measures the friction in the gearing of my locomotive by some magnifying standard of his own invention, without going into details. I will simply give an instance in our actual experience to illustrate the errror he has permitted himself to publish. In the presence of Mr. Adamson, general manager of the North Metropolitan Tramway Company, and several other gentlemen, I placed a locomotive upon the line, with a small motor connected according to my patents; the weight of the machinery and accumulators was 4 tons 17 cwt. I attached three empty cars to the locomotive, and with 1·5 mechanical horse-power upon my *motor spindle* I drew these three cars, weighing 7½ tons (in all about 12 tons), at a speed of about 2½ miles. If, then, according to the statement of "H. S.," I lose 1·3 horse-power in friction, there only remained 0·2 horse-power for the propulsion of 12 tons at a speed of 220ft. per minute. If I could, indeed, accomplish such a feat, I should be more deserving of the attainments of Hercules than of Archimedes I wish to state, finally, that I cannot in the future reply to carping letters like that of "H. S.," as I consider my time to be better occupied in proving by practical demonstration the success of my principle than in wandering over a dreary waste of useless figures at the will of every person who wishes to air his knowledge at the expense of the space of a scientific journal.

Should "H. S." or any of his collaborateurs desire to go into the details of my locomotive I would advise them to pay it a visit at the North Metropolitan Tramway Company's depôt at Stratford, where I shall be happy to show them practical work if they will apply previously to myself or the secretary of the company.—Yours, &c., C. P. ELIESON.

THE SOCIETY OF TELEGRAPH-ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your remarks as to the proceedings of the Society of Telegraph (?) Engineers and Electricians were very proper. I received my ballot paper a few days ago, and thoroughly disgusted with it I was. Amongst the nominees for places of honour I could not observe—except in one or two instances, where the "big ones" are again patted on the back—the single name of a gentleman practically connected with telegraphy proper; nor could I see the name of one man from the Provinces. London men divide all the honours amongst themselves, and we country supporters will soon have to ask ourselves whether the thing is worth the money. "The Society of Electric Light Engineers and Electricians" would be a more correct name than the present one, seeing that of all our highly-respected railway telegraph engineers and also telephone engineers not one of them is considered good enough to be placed on the Council, forsooth. I believe Mr. Spagnoletti was the first railway man to be elected President —a burning shame—and if he had not been a Londoner, goodness only knows when he would have received an invitation. Telegraph matters are now considered by the Council as of secondary importance, and telegraph men will soon begin to drop off the subscription list.—I enclose my card, and remain, yours, &c., BATTERY BOX.

RECKENZAUN'S ELECTRIC LAUNCHES.

When, last summer, the Duke of Bedford had a cruise in the electric launch "Australia" in company with Lord Sudeley and the designer of the yacht, Mr. Reckenzaun, his Grace recognised the usefulness of such a boat on board a steam yacht, and ordered a similar one, which he intended should be used both as a launch and an auxiliary for lighting his yacht by means of the accumulators.

This launch was tried last week at Westminster. It is 3ft. longer than the "Australia," but the internal arrangements are similar. Twenty-nine E. P. S. cells are placed in the centre under a board, which also forms a seat. The battery actuates a Reckenzaun motor, to which is coupled the shaft and propeller. The launch can run at the rate of six knots per hour, each charge supplying power at this rate of four hours and a half.

When suspended in the davits the accumulators in the boat can be used for lighting the yacht, and the charging of the cells is obtained from the dynamo that lights the yacht "Northumbria."

The charging of the cells is effected by the same dynamo that lights the ship, so that no special apparatus is necessary. The boat has been fitted throughout by the Electrical Power Storage Company, and contains several improvements in the manipulation and reversing gear on those previously made by this company.

There were present at the trial (which was most satisfactory) Lord Sudeley, Mr. White (Director of Naval Construction), and Major-General Webber, C.B., and the Storage Company was represented by Mr. J. Irving Courtenay, Mr. Bernard Drake, and Mr. J. W. Gorham.

We are informed that Mr. Reckenzaun has at this moment several designs in progress which will embody further substantial improvements in the electric launch. One of these designs is being executed to the order of the Italian Government, and is adapted for naval purposes; another is being executed to the order of an Indian prince. The latter is a pleasure boat, luxuriantly arranged with saloon and magnificent furniture. It is splendidly illuminated by means of incandescent lamps, and the ventilating fans are actuated also by electrical apparatus.

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LITERATURE.

Lectures on Heat, Sound, and Light. An Elementary Text Book for Students. By Richard Wormell, D.Sc., M.A. [Thomas Murby, 3, Ludgate-circus-buildings, E.C.]

Chemical Student's Manual, for the Lecture Room and the Laboratory. Embracing Non-Metals, the Analysis of Simple Salts, &c. By Herbert L. Buckeridge, F.C.S. [Thomas Murby, 3, Ludgate-circus-buildings, E.C.]

Dr. Wormell has long been recognised as an earnest teacher. He possesses a wide knowledge of the subjects upon which he writes, and, what is quite as important, great experience in teaching. We have read through many of the lectures or lessons in this book, and find the subject matter correct, well put, the illustrations apt, and to the point. The idea is to provide a progressive course for school work, extending over a period of about a year and a half or two years. At the end of each section a series of notes upon laboratory practice is given, and at the end a number of examination questions. If we ventured upon a suggestion, it would be to eliminate from a new edition all such paragraphs as "How to Make a Thermometer." No class of students at so early a stage in their scientific training could be expected to follow the directions given. Probably, Dr. Wormell in these paragraphs has not followed his own experience, but has given way to the foolish cry that students should make most of their own tools, and that by so doing the cost of teaching science would be lessened. With this exception we have nothing but praise for Dr. Wormell's work.

The second book mentioned above is of a different character altogether, and partakes more of the student's note book than of his text book. No doubt such books are of great service when used properly, but condensation does not always lead to information. As a *memoria technica* to a good course of lectures or exhaustive text books this work seems well adapted. The facts are well arranged and clearly stated.

SUBMARINE CABLES IN WAR.

In January, 1850, the French Government conceded to an English company the right to establish telegraph communication across the Channel by a submarine cable. Not till August, 1857, however, was the first attempt made to bridge the Atlantic, when the old "Agamemnon," since replaced, and the United States frigate "Niagara" started from Valentia Island with a cable which broke at the three hundredth mile, thus bringing the venture to an untimely end. Since that time, all the difficulties of cable manufacture have been overcome. Cables can be laid with certainty and rapidity, so that the world has been gradually girdled with the slender cords which annihilate space, and we in London to-day are able to speak to Australia as surely and in less time than was needed 100 years ago to communicate with Oxford. From Valentia Island, Falmouth, and Brest a belt of ten cables traverses the Atlantic, and strikes the opposite shores at St. John's, Newfoundland, and at Sydney, Cape Canso, and Torbay, Nova Scotia. Thence land lines cross North America to San Francisco, and trend north through British Columbia to remote Alaska. From Falmouth again, through Lisbon, Madeira, and St. Vincent, two cables slant down across the Atlantic to Pernambuco, in Brazil, whence one coast line leads northwards to Para, at the southern mouth of the Amazon, while another, bending south to the mouth of the Parana, connects with the land line crossing the Argentine Republic and Chili to Valparaiso, thence communicating with another coasting cable girdling the eastern shores of the Pacific through Callao and Panama to Tehuantepec. From Panama, a line crosses the isthmus to Colon and links with a cable which, passing north under the Caribbean Sea, unites at Kingston, Jamaica, with another line starting from Florida, and, running along the great chain of the West India Islands, ends at Georgetown, in British Guiana. Still another Atlantic cable leaves Lisbon and passes through the Canaries to Senegal. Eastwards from England, cables run down the Mediterranean from Gibraltar, Marseilles, Otranto, and Trieste to Alexandria, where one branch leads north east through Cyprus to Latakieh, and, connecting with overhead wires stretching down the valley of the Euphrates to the Persian Gulf, links with a cable landing ultimately at Kurrachee. Three cables pass down the Red Sea, of which one branches off from Aden through Zanzibar to Port Natal, thence communicating overland with the Cape; while the others continue their course to Bombay and couple up with land lines crossing Hindostan to Madras. From Madras, a cable leads south-east through Penang, Singapore, and the eastern angle of Java to Port Darwin, linking to the long land line which bestrides Australia to Port Augusta, and thence communicates, *vià* Melbourne, with Tasmania and, *vià* Sydney, with New Zealand. Branching off from this main line at Singapore, a cable leads to Saigon, and, passing up the China Sea to Hong Kong, skirts the coast to Shanghai, and crosses the Yellow Sea to Nagasaki, ending at Vladivostock, where it joins the great Russian land line, which completes the circuit back to Europe. Quite recently an independent line has been laid, coupling Hong Kong with Port Hamilton, near the southern point of the Corean Peninsula.

This vast system, which places London within a few hours of Alaska, the Cape of Good Hope, New Zealand, and the Okhotsk Sea, has grown up for the most part on no principles except those dictated by trade requirements, is under no sort of international protection in war time, has no defined *status* in international law. Strategically speaking, it is, from an English point of view, manifestly defective. The only communication with the important naval fortress of Hong Kong passes through Saigon, a French station. All communication with Gibraltar and Malta traverses French, Spanish, or Portuguese territory. The important stations of Sierra Leone and St. Helena are at present inaccessible, while Mauritius lies isolated in the Indian Ocean and Bermuda in the Atlantic. Along the Suez Canal route to India, cable communication is very complete, but would be somewhat precarious in war time. The long sea route, however, the great alternative on which alone England can securely reckon, is without any communication with the exception of the unreliable line *vià* Zanzibar to the Cape. The position of all the cable lines of the world is known with tolerable accuracy, and their destructibility varies practically with the depth of sea-bottom. It would probably be a long task to grapple for the North American lines in mid-ocean, considering that five weeks have been needed to find the line between Colon and Jamaica; but the shallow sea and the coasting lines would not be difficult to discover and to cut, while shore ends must, in many instances, be specially vulnerable. Thus, in a large number of cases, the possibility of preserving telegraph communication during war must depend mainly on naval activity. The Russians were reported to have made arrangement for cutting cables had war broken out this year, and it is evident that, if vessels specially equipped for the purpose can succeed in keeping the sea for any length of time, the amount of injury which could be effected would be very serious. Given speed, coal-endurance, and daring, this new method of damaging an enemy offers chances which are too well realised to be thrown away. The advantage of uninterrupted telegraph communication between a Minister of War and the headquarters of an army in the field is highly questionable, and a great general would probably find means to cut his cable upon occasion; but the strategic importance to England of maintaining telegraphic touch of her foreign stations can hardly be overrated. War ships are now dependent on the coaling stations, which give them the means of movement, and communication with these stations confers the power of naval concentration, and renders naval strategy possible in the higher sense, while it secures the timely warning which may mean safety. England has important stations which might be attacked in force long before the news of a declaration of war could reach them.

Broadly speaking, the danger to cables would be greatest at the outset of hostilities. As soon as England had definitely embarked on a great war, and had more time to develop her naval strength, and make her supremacy felt on the high seas, that danger would sensibly diminish. Cables can be repaired

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almost as easily as cut, since the main difficulty in either case is to find them. New lines can be rapidly laid. Ordinary foresight would, therefore, indicate that certain stations should always contain a large reserve of cable ready for emergencies, and that properly equipped laying and repairing ships should be available. The adoption of such an obvious measure of precaution might be taken for granted were it not that other vitally important measures have been openly neglected; while for years we have rested content with a scarecrow defence for the coaling stations on which the Empire may any day depend.

It is doubtful to-day if half the members of the House of Commons could give their mere names, so superior are the fascinations of parochial matters to those of high Imperial affairs. Complex and conflicting interests have grown up around the giant cable system of the world, some of which are worth noticing. Assuming that France, during a war with England, were to cut the Mediterranean or Red Sea cables, she would deprive herself of all possible telegraphic touch with her Indo-Chinese possessions; since messages even if sent across Asiatic Russia to Vladivostock would be liable to interception at Hong Kong before reaching Saigon.

Moreover, to cut these cables would not deprive England of communication *viâ* Constantinople and the Persian land lines with India, and thence with Singapore, Australia, and New Zealand. England would have lost touch of the Cape, but could still speak to Aden *viâ* Bombay. On the other hand, since France could in no case feel assured of communication with Saigon and Tonquin—messages for either having to pass through Hong Kong or Singapore—the supposed measure might not only recommend itself, but might perhaps be supplemented by an effort to cut the Persian Gulf line to Kurrachee, the Aden-Bombay, the Madras-Penang, and the Rangoon-Penang lines, the total effect of which would be to telegraphically isolate England from India and India from Penang and Singapore, with the incidental result of seriously interfering with Dutch interests in Java, Spanish interests in the Phillippines, and possibly German interests at Zanzibar.

Supposing, however, that it was open to England to communicate *viâ* Russia and Vladivostock, a further cable cutting in the Yellow Sea or at Foochow and Amoy would be needed to isolate Hong Kong. The North American cables might remain intact, since they deeply affect American interests, while they are relatively less vulnerable on account of their multiplicity and great depth. Again, to cut the West Indian cable would be to interrupt communication with the French islands; but, since all messages pass through Jamaica, France might elect to cut the line between Kingston and Santiago, Cuba, ignoring the interests of the owners of islands to the westwards, but would have further to cut the Colon-Kingston line to isolate Jamaica. England, on her part, might attempt to cut the Brest cables, thus concentrating all communication with North America at Falmouth and Valentia; while she would probably cut the Senegal line between the Canaries and St. Louis.

The two cables from Marseilles to Algiers and from Marseilles to Bona might similarly be threatened by England, but the military advantages of cutting an enemy's communications diminish with their length, and the operation would not be particularly valuable.

Russia could hope for little from cables in a war with England, and all her own communications being interior land lines, she might elect to cut cables freely with the certainty of injuring English interests. While, however, she might seek to isolate Hong Kong and the Australian colonies, she could not interfere with the lines west of Singapore without touching French interests in Cochin-China and Tonquin, while eventually German interests may come to be involved in the cable to Zanzibar.

Thus, putting the North American lines out of consideration for the reasons above stated, it might be anticipated that Russia would seek to effect interruption north of Saigon, between Java and Port Darwin, and between Mozambique and Port Natal, with a view to isolate Hong Kong, the Australian colonies and New Zealand, and the Cape respectively. Mediterranean communications would, perhaps, not be threatened, and even if an interruption of the Persian land lines could be arranged, touch with India would probably be maintained.

Spain might conceivably seek to sever England's touch with Gibraltar, Italy to isolate Malta, England retaliating by cutting the Otranta line to Alexandria; but in this case many other interests would be affected and considerable inconvenience would be inflicted on neutrals without any great military advantage being gained by either side.

Combinations of Powers might have been assumed, but enough has been said to show how involved are the interests concerned and how conflicting the advantages to be reaped by cable-cutting. This alone will probably prove some safeguard to cables, and will at least serve to prevent mere random destruction. On the other hand, it is evident that of all Powers England has most to lose by the interruption of telegraph communication, while by retaliation she has little to gain. Thus far it has been assumed that the cutting of cables will play an important part in war, and that, as a weapon against England, it may be employed in spite of the commercial and other injury entailed upon neutrals. The whole question of cable-cutting is, however, one of which we as yet have no experience, and while it may be safely assumed that the rights, real and asserted, of weak neutrals will receive scant recognition, cases may occur in which the international aspects of cables cannot be lightly put aside.

International law is a vague term requiring much qualification. Great Powers agree formally that certain conditions shall be observed by them in war, or, by long observance, certain unformulated conditions win the sanctity of custom. This practically means merely that neither of two belligerents will go so far in contravention of this so-called law as to bring a powerful neutral into the field, and that neither is likely to commit any act which would bring upon it such a measure of moral opprobrium as might count as an adverse factor in its subsequent dealings with other nations. Weak Powers, unprovided with a strong backer, and semi-civilised Powers have reaped little benefit during war from international law in the past, and are unlikely to be able to calculate with certainty on its provisions in future. *Force majeure* can be advanced in justification of most questionable acts. When, in 1807, England suddenly seized the Danish fleet the act was probably indefensible under international law, while certain of the recent French proceedings at Foochow would tax the ingenuity of an advocate. While, however, international law has attempted to formulate regulations more or less definite with respect to such matters as contraband of war, submarine cables—either because their existence is too recent or because the questions relating to them are too complex and delicate—have not been brought within the scope of any understanding, formal or otherwise. It is true that the protection which an international agreement would promise could hardly be relied upon with any degree of certainty. Anchors might innocently foul important cables, and in weighing them it is only natural that the cables might be broken, just as no neutralisation of the Suez Canal will ever prevent vessels from accidentally sinking across it at critical periods. The grave inconvenience to neutrals which cable-cutting on a large scale would entail might, however, at least have led to an attempt to arrive at some sort of mutual understanding. It is worth while to consider a few of the questions which may any day present themselves. Despatches conveyed to a neutral by a belligerent are, of course, contraband of war. Are telegraph messages contraband, and may such messages, ocean borne, pass through a neutral station? Supposing France and Russia to be at war, can the Russians claim that no messages shall be sent over a British owned cable to Saigon? It is clear that such messages might possess military importance, while to stop them would practically mean that no telegraph messages could pass from Singapore to Saigon.

Even then sham messages, ostensibly for Hong Kong, might be read off at Saigon and might tell all that was needed. Have the Russians the right to cut the cable between Singapore and Hong Kong? This would compel all messages from England

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for Hong Kong to pass through Vladivostock, an arrangement for which England might not greatly care. England and France are at war. Despatches for Halifax and Jamica are contraband. Has France the right—assuming that she has the power—to cut the Atlantic cables? To do so would be an almost intolerable nuisance to the United States, and would paralyse the business of New York. Again, how far does the ownership of cable lines affect the right to cut them, and could an American-owned line claim an immunity in this case which a British cable did not possess? France and the United States are the belligerents—are the British-owned cables liable to be cut on account of the value they would unquestionably possess for the United States? It might be argued that in mid-ocean they were the property of a neutral, but that within the territorial three miles of the American coast they were as destructible as a British-owned land line on belligerent soil. The above are only specimens of the class of questions which it is more easy to propound than to answer. Such questions may any day arise in the conflict of interests involved in cables in the capacity of transmitters of information of direct and indirect military importance, and in their civil capacity as international channels of communication by which the whole machinery of the vast commercial system of the world is moved.

Only last year the protection of cables in peace time formed the subject of an international conference. A series of measures were agreed upon and now form a part of international law under which wilful or culpable damage to a cable is punishable in Consular Courts. It is remarkable that not only was no attempt made to exchange views on the far more important question of the position which cables are to occupy in time of war, but a clause was adopted which seems capable of being construed into an invitation to cut cables ruthlessly.

By Article XV. it is provided that "the stipulations of the present Convention do not in any way restrict the freedom of action of belligerents." The Belgian representatives alone appear to have grasped the absurdity of this clause, and have placed on record their view that Article XV. is "absolument inutile aux yeux du Gouvernement Belge." Of all powers England is most interested in securing the sanctity of cables. Having little to gain by cutting them, she has much to lose as a neutral and as a belligerent by having them cut by other people. Guileless of any special qualification for dealing with such a question, and, as usual in such cases, unprovided with naval or military advisers, the British representative adopted, if he did not frame, a clause which will at least serve to render future negotiations more difficult. The clause is "absolutely useless," as the Belgians point out; this much will be generally conceded. The fact remains that the British Government, or its representative, was unable to see that anything which makes for the education of international opinion as to the neutralisation of cables makes for the interests of England, and was anxious to claim for her a freedom of action which, in default of all existing restrictions, no Power requires, and which she in particular does not really want. Of the 25 Governments represented at Paris some at least would probably have welcomed any proposal which tended towards the preservation of cable communications in war. If cable-cutting came into fashion and were elevated, or reduced, to a science, the position of neutral Powers would be lamentable, and it is even conceivable that the first military Power of the age would have been found willing to further the cause of civilisation by any measure directed towards the neutralisation of cables. It is useless to blind ourselves to possibilities we may have to face, and a cool consideration of these possibilities can do no harm. England being neutral, the seizure of a British ship by a belligerent would, under certain circumstances, constitute an act of war. The actual injury inflicted would be the merest trifle in comparison with that entailed by the cutting of certain cables. Is it permissible under any circumstances for a belligerent to cut those cables; or is England prepared to make the cutting of them a *casus belli* and to proclaim her intention in advance? On this point it is as well that we should make up our minds.—*The Times.*

ELECTRIC LIGHT LICENSE.

The following is a verbatim copy of one of the licenses issued by the Board of Trade, which can thus be used as a reference in the future by all interested in the subject:—

DALTON-IN-FURNESS ELECTRIC LIGHTING.

License authorising the Local Board for the District of Dalton-in-Furness, in the County of Lancaster, to erect and maintain Electric Lines and Works, and to supply Electricity, within the District of the said Local Board.

Preliminary.

1. This License may be cited as "The Dalton in-Furness Electric Lighting License, 1885."

2. This License is to be read and construed subject in all respects to the provisions of the Electric Lighting Act, 1882, and of any other Acts or parts of Acts incorporated therewith, which said Act and Acts and parts of Acts are in this License collectively referred to as "the principal Act;" and the several words, terms, and expressions to which by the Electric Lighting Act, 1882, meanings are assinged shall have in this License the same respective meanings, provided that in this License—

The expression "main" shall mean any continuous metallic conductor which may be laid down by the Undertakers in any street or public place, and through which electricity may be supplied or intended to be supplied by the Undertakers for the purposes of general supply:

The expression "distributing main" shall mean the portion of any main which is used for the purpose of giving origin to any service line for the purposes of general supply.

The expression "service line" shall mean any continuous metallic conductor used or intended to be used by the Undertakers for the supply of electricity to any particular consumer, either from any main or directly from the premises of the Undertakers.

The expression "general supply" shall mean the supply of electricity to ordinary consumers, and, unless otherwise specially approved of by the Board of Trade either generally or in respect of individual cases, to the public lamps, but shall not include the supply of electricity to any one or more particular consumers under special agreement.

The expression "the area of supply" shall mean the area within which the Undertakers are for the time being authorised to supply electricity under the provisions of this License:

The expression "The District" shall mean the Local Government District of Dalton-in-Furness as the same is constituted at the date of the commencement of this License:

The expression "The Local Board" shall mean the Local Board for the District:

The expressions "Schedule A." and "Schedule B." shall mean the Schedules A. and B. to this License annexed respectively.

3. This License shall come into force and have effect upon the first day of December, 1885, which date is in this License referred to as "the commencement of this License," and shall continue in force for a period of seven years from the commencement thereof, which period is in this License referred to as "the term of this License."

Description of the Undertakers.

4. The Undertakers for the purposes of this License shall be the Local Board: Provided that if the Local Board transfer all the powers, duties, and liabilities by this License conferred or imposed on them with reference to the supply of electricity in the district or any part thereof to any other body or person under the provisions of this License, such body or person shall be the Undertakers for the purposes of this License in respect of such area, as from the date of such transfer.

Area and Mode of Supply.

5. Subject to the provisions of this License and of the principal Act, the Undertakers may supply electricity within the district for all public and private purposes as defined by the said Act, provided that such electricity shall be supplied only by means of some system which may have been approved of by the Board of Trade either for general or special use, and subject to such regulations and conditions for securing the safety of the public, and for ensuring a proper and sufficient supply of electricity as the Board of Trade may from time to time impose, and that under no such system shall the Undertakers permit any part of any circuit to be connected with earth, except as so far as may be necessary for carrying out the provisions of any such regulations or conditions as aforesaid unless such connection is hereafter approved of by the Board of Trade, with the concurrence of the Postmaster-General.

Lands.

6. Subject to the provisions of this License and the principal Act, the Undertakers may from time to time, by agreement, purchase or take on lease any lands for the purposes of this License, and may use such lands, and any other lands which may for the time being belong to or be vested in or leased by them and may not be dedicated to the public as a park or recreation ground or be appropriated as a cemetery for the purposes aforesaid, and may from time to time dispose of any lands acquired by them under the provisions of this section which may not for the time be required for the purposes of this License: Provided that the amount of land so used by them shall not at any one time exceed in the whole five acres, except with the consent of the Board of Trade.

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Works.

7. Subject to the provisions of this License and the principal Act, the Undertakers may from time to time exercise all or any of the powers conferred on them by this License and the principal Act, and may break up or otherwise interfere with so much of the railway and tramways specified in Schedule B. to this License as may for the time being be included within the area of supply, so far as the same may be or be upon any land dedicated to public use, and they may from time to time construct distributing boxes in any street for the purpose of supplying electricity.

Every such distributing box shall be for the exclusive use of the Undertakers and under their sole control, except so far as the Board of Trade may otherwise order, and shall be used by the Undertakers only for the purpose of leading off service lines and other distributing conductors, or for examining, testing, regulating, measuring, directing, or controlling the supply of electricity, or for examining or testing the condition of the mains or other portions of the electric lines or works, or for other like purposes connected with the undertaking, and the Undertakers may place therein meters, switches, and any other suitable and proper apparatus for any of the above purposes, and may maintain and use the same.

8. Where the exercise of any of the powers of the Undertakers in relation to the execution of any works (including the construction of distributing boxes) will involve the placing of any works in, over, along, or across any street or public bridge, the following provisions shall have effect:—

(*a.*) One month before commencing the execution of such works (not being repairs, renewals, or amendments of existing works of which the character and position are not altered), the Undertakers shall serve a notice upon the Postmaster-General, describing the proposed works, together with a plan of the works showing the mode and position in which such works are intended to be executed and placed, and shall, upon being required to do so by the Postmaster-General, from time to time give him any such further information in relation thereto as he may desire.

(*b.*) The Postmaster-General may in his discretion approve of any such works or plan, with or without any amendment or alteration, or disapprove of the same, and may give notice of such approval or disapproval to the Undertakers.

(*c.*) Where the Postmaster-General disapproves of any such works or plan the Undertakers may appeal to the Board of Trade against such disapproval, and the Board of Trade may inquire into the matter, and may allow or disallow such appeal, and approve of any such works or plan, with or without any amendment or alteration, or disapprove of the same:

(*d.*) If the Postmaster-General fail to give any such notice of approval or disapproval to the Undertakers within three weeks after the service of the notice upon him, he shall be deemed to have approved of such works or plan.

(*e.*) Notwithstanding anything in this License, or the principal Act, the Undertakers shall not be entitled to execute any such works as above specified, except so far as the same may be of a description and in accordance with a plan which has been approved of or is to be deemed to have been approved of by the Postmaster-General, or by the Board of Trade as above mentioned under this License; but where any such works and such plan are so approved of or to be deemed to be approved of, the Undertakers may cause such works to be executed in accordance with such plan, subject in all respects to the provisions of this License and of the principal Act.

(*f.*) If the Undertakers make default in complying with any of the requirements or restrictions of this section they shall (in addition to any other compensation which they may be liable to make under the provisions of this License or the principal Act) make full compensation to the Postmaster-General for any loss or damage which he may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding ten pounds for every such default, and in case of a continuing offence to a further penalty not exceeding five pounds for every day after the first day during which such default continues; provided that the Undertakers shall not be subject to any such penalties as aforesaid if the Court having cognisance of the case are of opinion that the case was one of emergency, and that the Undertakers complied with the requirements of this section so far as was reasonable under the circumstances.

9. Where the exercise of the powers of the Undertakers in relation to the execution of any works will involve the placing of any works in, over, along, or across any street or part of a street, not repairable by the local authority, or any railway, tramway, or canal, the following provisions shall have effect unless otherwise agreed between the parties interested:—

(*a.*) One month before commencing the execution of any such works (not being the repairs, renewals or amendments of existing works, of which the character and position are not altered), the Undertakers shall, in addition to any other notices which they may be required to give under this License or the principal Act, serve a notice upon the body or person liable to repair such street or part of a street, or the body or person for the time being entitled to work such railway or tramway, or the owners of such canal, as the case may be (in this section referred to as "the owners"), describing the proposed works, and stating the amount of compensation proposed to be made in respect thereof, and the manner in which such compensation is proposed to be paid or secured, together with a plan of the works showing the mode and position in which such works are intended to be executed and placed, and shall, upon being required to do so by any such owners as aforesaid, from time to time give them any such further information in relation thereto as they may desire.

(*b.*) Every such notice shall contain a reference to this section, and direct the attention of the owners to whom it is given to the provisions thereof.

(*c.*) Within three weeks after the service of any such notice and plan upon any owners, such owners may, if they think fit, serve a requisition upon the Undertakers requiring that any question in relation to such works and any other question arising on any such notice or plan as aforesaid shall be settled by arbitration; and thereupon such question shall be settled by arbitration accordingly.

(*d.*) In settling any question under this section an arbitrator shall have regard to any duties or obligations which the owners may be under in respect of such street or part of a street, railway, tramway, or canal, and may, if he thinks fit, require the Undertakers to execute any temporary or other works so as to avoid interference with any traffic so far as may be possible.

(*e.*) Where no such requisition as in this section mentioned is served upon the Undertakers, or where, after any such requisition has been served upon them, any question required to be settled by arbitration has been so settled, the Undertakers, upon paying or securing any compensation which they may be required to pay or secure in the manner proposed by them or settled by arbitration as aforesaid, may cause the works specified in such notice and plan as aforesaid to be executed, and may from time to time repair, renew, and amend the same (provided that their character and position are not altered), but subject in all respects to the provisions of this License and the principal Act, and only in accordance with the notice and plan so served by them as aforesaid or such modifications thereof respectively as may have been settled by arbitration as hereinbefore mentioned, or as may be agreed upon between the parties.

(*f.*) If the Undertakers make default in complying with any of the requirements or restrictions of this section they shall (in addition to any other compensation which they may be liable to make under the provisions of this License or the principal Act) make full compensation to the owners affected thereby for any loss or damage which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding ten pounds for every such default, and in case of a continuing offence to a further penalty not exceeding five pounds for every day after the first day during which such default continues; provided that the Undertakers shall not be subject to any such penalties as aforesaid if the Court having cognizance of the case are of opinion that the case was one of emergency, and that the Undertakers complied with the requirements of this section so far as was reasonable under the circumstances.

10. Any body or person for the time being liable to repair any street or part of a street or entitled to work any railway or tramway which the Undertakers may be empowered to break up for the purposes of this License, if they think fit, may from time to time serve a notice upon the Undertakers stating that they desire to exercise or discharge all or any part of any of the powers or duties of the Undertakers as therein specified in relation to the breaking up, filling in, reinstating, or making good any such street or part of a street, railway or tramway (as the case may be), and may from time to time amend or revoke any such notice by another notice similarly served.

Where any such body or person as aforesaid (in this section referred to as "the givers of the notice") have given notice that they desire to exercise or discharge any such specified powers or duties of the Undertakers, then so long as such notice remains in force the following provisions shall have effect unless otherwise agreed between the parties interested:—

(*a.*) The Undertakers shall not be entitled to proceed themselves to exercise or discharge any such specified powers or duties as aforesaid, except where they shall have required the givers of the notice to exercise or discharge such powers or duties, and the givers of the notice have refused or neglected to comply with such requisition, as hereinafter provided, or in case of emergency.

(*b.*) In addition to any other notices which they may be required to give under the provisions of this License or the principal Act, the Undertakers shall, not more than forty-eight hours and not less than twenty-four hours before the exercise or discharge of any powers or duties so specified as aforesaid is required to be commenced, serve a requisition upon the givers of the notice stating the time when such exercise or discharge is required to be commenced and the manner in which any such powers or duties are required to be exercised or discharged.

(*c.*) Upon receipt of any such requisition as last aforesaid, the givers of the notice may proceed to exercise or discharge any such powers or duties as required by the Undertakers, subject to the like restrictions and conditions as the Undertakers would themselves be subject to in such exercise or discharge so far as the same may be applicable.

(*d.*) If the givers of the notice decline, or for twenty-four hours after the time when any such exercise or discharge of any powers or duties is by any requisition required to be commenced neglect, to comply with such requisition, the Undertakers may themselves proceed to exercise or discharge the powers or duties therein specified in like manner as they might have done if such notice as aforesaid had not been given to them by the givers of the notice.

(*e.*) In any case of emergency the Undertakers may themselves proceed to at once exercise or discharge so much of any such specified powers or duties as aforesaid as may be necessary for the actual remedying of any defect from which the emergency arises without serving any requisition on the givers of the notice.

(*f.*) If the Undertakers exercise or discharge any such specified powers or duties as aforesaid otherwise than in accordance with the provisions of this section, they shall be liable to a penalty not exceeding ten pounds for every such offence, and in the case of a continuing offence to a further penalty not exceeding five pounds for every day after the first day during which such offence continues.

(*g.*) All expenses properly incurred by the givers of the notice in complying with any requisition of the Undertakers under this section shall be repaid to them by the Undertakers.

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(*h*.) The givers of the notice may from time to time, if they think fit, require the Undertakers to give them such security for the repayment to them of any expenses to be incurred by them under this section as may be agreed upon between them and the Undertakers, or in default of agreement as may be determined by arbitration. If the Undertakers fail to give any such security within seven days after being required to do so or in case of difference after the delivery of the arbitrator's award, they shall not be entitled to serve any further requisition upon the givers of the notice requiring them to exercise or discharge any powers or duties under this section, until such security has been duly given.

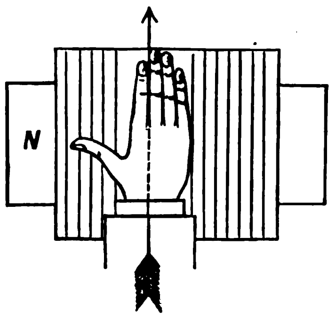
Provided that nothing in this or the last preceding section shall in any way affect the rights of the Undertakers to exercise or discharge any powers or duties conferred or imposed upon them by this License or the principal Act, in relation to the execution of any works beyond the actual breaking up, filling in, reinstating, or making good any such street or part of a street, or any such railway or tramway, as in this section mentioned.

(*To be continued.*)

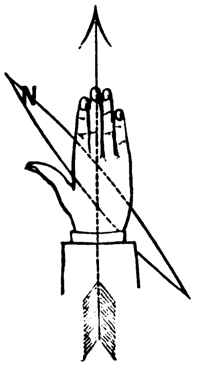
RULE OF THUMB FOR FINDING DIRECTION OF CURRENT AND NORTH POLE OF MAGNETS.

BY J. D. F. ANDREWS.

Knowing the direction of current in the wire of an electro-magnet, then the thumb of the right hand will point to the N. pole when the palm of the hand is placed on the coil, with the fingers parallel to the wires, and pointing in the direction of the current.



Knowing the N. pole of a magnet, then the fingers will point in the direction of the current when placed parallel with the wires, with the palm of the hand on the coil and the thumb pointing to the N. pole.



The N. pole of a magnetic needle will deflect towards the thumb of the right hand when the palm is placed on the wire, with the fingers parallel to it pointing with the direction of the current producing the deflection. Conversely, if a magnetic needle deflects towards the thumb of the right hand, with the palm on a wire over the needle and the fingers parallel with the wire, then the fingers will point with the direction of the current. The above rules are exceedingly handy in the construction of dynamos, and are easily remembered by workmen who have to connect up the coils, &c.

ELECTRICAL SAPONIFICATION.—Professor Rotondi has recently completed his experiments upon the application of electricity to the decomposition of concentrated salt solution into caustic soda and chlorine gas for commercial purposes. He has found that with a dynamo and diaphragms the process of saponification is easily effected by means of common salt and fat. The separation of the resultant products, glycerine, soap, and chlorine gas is a matter of no difficulty. No caustic soda is necessary for saponification.

LIGHTHOUSE ILLUMINANTS.—ELECTRIC LIGHT APPARATUS.

REPORT OF PROF. W. GRYLLS ADAMS, F.R.S., &c.

(*Continued from page 78.*)

According to Fresnel's formula the reflection of light from the surfaces of this lens amounts to 8·3 per cent. of the whole; hence in using this photometer the illuminating power of the arc may be determined within a distance of 5 feet from the arc, and 8·3 per cent. must be added on to the results obtained to allow for the light reflected from the surfaces of the glass.

In order to test the accuracy of the method, measurements of the light were taken with the lens at different distances from the arc, thus introducing a different multiplying factor for each case.

Thus, with the lens at a distance of 100 inches from the arc, the value $\left(\frac{u-f}{f}\right)^2 = 2,607$, several series of observations were made for intensity of illumination. The difference of colour of the lights was got rid of by observing through ruby glass and also through the blue solution of ammonia sulphate of copper.

The following were the results :—

For red light, 16,440 candles.
For blue light, 35,660 candles.

Another set of observations was made with the lens at a distance of 73 inches from the arc.

The multiplying factor in this case was 1,354.

The following were the results :—

For red light, 15,934 candles.
For blue light, 36,030 candles.

Observations were also made with an orange glass, which gave an illumination of 19,900 candles.

For the sake of comparison with these measurements, a series of measurements was also made with the pentane gas flame and the shadow photometer, making observations of the shadows by looking through the same red glass and ammonia sulphate of copper solution to see when the shadows were of equal intensity.

The observations were made in the photometric gallery at a distance of 140 feet from the arc, and the mean results arrived at were :—

For red light, 12,300 candles.
For blue light, 20,580 candles.

On the same day Sir J. Douglass compared his standard light with the catoptric light from a 21 inch reflector and double-wick Douglass oil burner, and found the catoptric light to be 6,130 candles.

He then compared directly the catoptric light with the electric light by means of Bunsen's photometer, and this gave an illumination of very nearly 18,390 candles for the light of the electric arc.

During these experiments the average E.M.F. at the extremities of the arc was 35 volts, and the average current 180 amperes from machine L No. 2, giving 6,300 as the average power in watts.

Measurements in the Photometric Gallery.

On November 10th measurements were again made to test the efficiency of the machines and the power employed in driving them when supplying an arc in the photometric gallery. Three separate determinations showed that 13·8 h.p. was consumed in producing 170 amperes of current with an electromotive force of 43 volts at the terminals of the machines, giving the average power of 7,300 watts.

This gave an electromotive force of 35·5 volts at the extremities of the arc, making the average power consumed in the arc about 6,030 watts. The light given in this case, as measured by red light, was 8,230 candles, and by blue light 18,600 candles.

Two machines were then employed to supply one arc in the photometric gallery, when there was a consumption of 28·5 h.p., giving a current of 286 amperes, with an electromotive force of 46 volts, giving an average of 13,150 watts in the external circuit.

This gave an electromotive force of 34 volts at the extremities of the arc, making the average power consumed in the arc in the photometric gallery about 9,720 watts.

The light given in this case, as measured by red light, was 16,000 candles, and by blue light was 23,000 candles.

The single engine which was used for these experiments was not found to be powerful enough to drive the three machines at full power.

On December 18th, when employing the three machines in parallel circuit to send a current through one arc in the photometric gallery, the power expended (as deduced from indicator diagrams taken on the engine) was 40·5 h.p. (nett), which gave an E.M.F. of 55 volts and a current of 333 1 amperes, or 18,320 watts, *i.e.*, 24·56 h.p., giving an electrical efficiency of 61 per cent. in the external circuit.

When the two machines, L No. 1 and L No. 2, were worked together under the same conditions as in the previous case, the power expended by the engine was 28·44 h.p., which gave an E.M.F. of 50 volts and a current of 285 amperes, or on an average 14,250 watts, *i.e.*, 19·1 h.p., giving an electrical efficiency of 67·2 per cent. in the external circuit.

This confirms the results obtained under the same circumstances on November 10th.

The efficiency of the single machines was not tried on this occasion.

In measuring the intensities of light in the photometric gallery on December 18th during these experiments, the Douglass standard (1 candle) and the Bunsen or star disc were joined together, and the slit of the Douglass was one foot from the disc. This standard was afterwards measured by the pentane standard, and was found to be 1,093 candles.

A copper ruby glass was made use of in these experiments to compare the electric light with the yellow light of the Douglass burner.

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With the current from three machines two sets of observations were made at two different distances, *i.e.*, 100 inches and 84 inches from the arc with the Hopkinson photometer; the two values obtained from the mean of these sets were 11,956 and 11,913 candles.

With the current from two machines several distinct sets of observations were made with the Hopkinson photometer, looking at the disc through ruby glass to compare the two lights.

The values obtained were 7,197, 9,183, 8,496, 6,273, and 8,590 candles.

The mean of all these results gives 7,948, or about 7,950 candles by red light.

Engine Room Experiments.

The arc lamp was now transferred to the engine room in order to determine the efficiency of the machines when supplying the electric current to the single arc without having external resistance in the leads.

This will give the efficiency of the machines when worksd as they are intended to be in lighthouses, where the lamp and the magneto machine should be placed not far apart from one another.

An expenditure of 14·2 h.p. gave an electromotive force of 43 volts and a current of 221 amperes, making an average of 9,500 watts, as compared with 170 amperes and 7,300 watts, when the arc was in the photometric gallery.

In this case the electrical energy in the external circuit is equivalent to from 12·25 to 12·75 h.p., and the efficiency is about from 86 per cent. to 88 per cent. (externel efficiency).

A similar experiment was now made with two machines supplying the electric current to one arc in the engine room. The horse-power expended was now found to be 28 45 h.p., giving an electromotive force of 41 volts and an average current of 410 amperes, making an average of 16,810 watts, equivalent to 22·54 h.p., as compared with 43 volts and 285 amperes, or 13,150 watts for the same h.p., expended by the engine when the arc was in the photometric gallery.

In this case, working two machines on one arc, the external efficiency is 79 2 per cent.

These experiments show the great advantage to be derived from placing magneto machines for lighthouse work as near as possible to the electric amp as to make the resistance of the connecting wires as small as possible.

On trying the three machines cn one arc it was found that the engine was not powerful enough to keep the three machines at full power.

On January 24, 1885, experiments were made with the arc lamp in the engine room, and an attempt made to measure the light given out as well as the current and electromotive force.

(1.) With one machine.

The electromotive force, as well as the current, was slightly lower than on December 18th last, the E.M.F. being about 37 volts and the current 222 amperes from one machine, when the light given by the arc was 14,730 candles or 13,450 candles.

Another series of experiments gave an electromotive force of 33·5 volts and a current of 227·5 amperes, giving as the average value 7,620 watts. During this series of experiments the light varied between 13,000 and 17,350 candles, the mean value being 14,000 candles.

(2.) With two machines supplying current to one arc, using the Siemens Berlin core 40 mm. carbons, two distinct sets of experiments were made, first with the Douglass standard candle (1·093 candles according to the Harcourt pentane flame standard), and afterwards with the full opening, giving 4·2 candles.

The first set of observations gave an illuminating power of 32,670 candles, and a second set of experiments gave a mean value of 24,710 candles.

The mean electromotive force was 41 volts, and the current varied from 378 to 414 amperes, the mean current being 395 amperes, giving the average power 15,960 watts expended in the arc.

Some new De Meritens solid 50 mm. carbons were now placed in the lamp, instead of the Siemens 40 mm. Berlin core carbons, with the following results:—

The average E.M.F. for 15 minutes previous with the Berlin core carbons was 39 volts, and the current 404 amperes, and the average light was 24,850 candles. But with the De Meritens carbons the average E.M.F. was 34 volts and the current 420 amperes, the average light being 17,420 candles. The De Meritens carbons did not give as good a light as the Berlin core 40 mm. carbons.

Experiments of February 28th and March 7th in the Engine Room.

In these experiments measurements were made of the electromotive force and current with a single machine and with two machines supplying the electric current to a single arc, and the intensity of the illumination was measured by means of the Hopkinson photometer, making use of the Douglass standard at a distance of 32 feet from the arc. Red and green glasses and a blue solution (ammonia sulphate of copper) were employed to compare the light of different colours given by the electric light and by the standard.

Taking 4·2 as the value of the Douglass standard throughout these experiments, the following are the values of the light given in the experiments:—

On February 28th, with one machine, the following values were obtained:—

E.M.F.	Current.	Light.	Colour.	Means.		
				E.M.F.	Current.	Light.
40	213	7,240	Red	—	—	—
35·3	225	13,980	Green	37	221	13,000
35	225·7	17,950	Blue	—	—	—

On March 7th, under the same circumstances, with one machine, the values were:—

E.M.F.	Current.	Light.	Colour.	Means.		
				E.M.F.	Current.	Light.
42	202	8,230	Red			
40	203·5	12,880	Green	40·2	204·2	12,650
38·7	207	16,830	Blue			
40	203·8	7,230	Red			
37	207·5	17,250	Green	38	206·6	15,960
37	208·5	23,410	Blue			

With two machines, the following series of values were obtained:—

—	E.M.F.	Current.	Light.	Colour.	Means.		
					E.M.F.	Current.	Light.
	46·6	377·7	14,340	Red			
Feb.28	47·5	376·6	32,280	Green	47·8	371·6	30,470
	49·3	360·5	44,790	Blue			
	51·6	354·5	13,080	Red			
	53·6	342·5	27,670	Green	52·2	350·7	29,620
	51·5	355	48,120	Blue			
	50	361	15,320	Red	—	—	—
	50·5	370	15,920	Red			
	52·7	361	24,860	Green	52·5	358·5	28,860
	54·3	344·5	45,800	Blue			
	62	303	13,770	Red			
	50	379	28,320	Green	55·3	343	29,170
	54	350	45,410	Blue			

It will be seen that usually the arithmetic mean of the observations for red, green, and blue light gives a result somewhat less refrangible than green, *i e*, between the yellow and the green in the spectrum.

An attempt was made to estimate the value of the light by direct comparison with the standard without any coloured medium, but it was more difficult to estimate the equality of the lights differing so much in colour.

The values obtained in the observations with two machines arranged for quantity were:—

—::—	E.M.F.	Current.	Light.
February 28...............	48·3	372	27,450
March 7	60	325	18,400
	55	341·4	21,870

There were very considerable variations of the light, depending on the variations of electromotive force and current. It will be seen that as the E.M.F. is diminished, the current increases, and as the current increases the light also seems to increase.

(To be continued.)

PHYSICAL SOCIETY—November 28th, 1885.

Mr. T. H. Blakesley was elected a member of the Society.

The following communications were read—"On the Calibration of Galvanometers by a Constant Current," by Mr. T. Mather. A current is passed through the coils of a galvanometer, which may be of any form; the galvanometer is turned in a horizontal plane through any angle, which need not be recorded, and the deflection θ of the needle noted. The current is then broken, and the needle swings back, taking up its position in the magnetic meridian; the angle through which it turns to do this is also noted, δ. This is repeated with the galvanometer in various positions, and with the same current, and a curve is drawn showing the relation between the values of $\frac{\sin\theta}{\sin\delta}$ and corresponding values of θ. When the instrument is now used in its normal position, it is readily seen that a current producing a deflection, θ, of the needle is proportional to the value of $\frac{\sin\theta}{\sin\delta}$ corresponding to θ obtained in the calibration experiment which may be read off at once from the curve.

"On a Machine for the Solution of Cubic Equations," by Mr. H. H. Cunyngham. This machine the author believes to be the only one hitherto constructed that gives the imaginary as well as the real roots of a cubic equation. A cubical parabola is drawn upon paper the ordinates being the cube roots of the corresponding abscissæ. To find the roots of a cubic, first reduce it by Cardan's rule to the form $x^3 - Ax - B = 0$. Then measure off along ox a distance equal to B, and from this point, T, draw a line, making an angle equal to $\cot^{-1}$ A with ox. The ordinates of the points where this line cuts the curve are the roots of the equation. To find the imaginary roots when they exist, first find the real root, as before; from this point draw a tangent to the branch of the curve the other side of oy, then if this line cut the axis of x at a point Q, and α be the real root, the two imaginary roots are

$$\frac{\alpha}{2} \pm 2\sqrt{\frac{QT}{\alpha}}$$

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Instead of actually going through the construction as above, the operation is preferably performed by applying a protractor with a tangent scale to the curve with its centre at T, setting it, and leading off the point of the curve cut by its edge.

"On a Machine for the Solution of Equations," by Mr. C. V. Boys. After mentioning Mr. Hinton's apparatus, lately shown to the society, and briefly describing Mr. Kempe's equation machine, Mr. Boys explained a machine he had constructed, consisting of a system of beams, each provided with a pair of pans, and working upon a fulcrum at the middle. The pans of the first beam are marked $+a$ and $-a$, those of the second $-b$ and $+b$, the next $+c$ and $-c$, and so on. Into these, weights equal in value to the coefficients a, b, c, &c., of an equation $a+bx+cx^2+\ldots\ldots=0$ are to be placed. A sliding joint is arranged to connect a point opposite the positive pan of each beam with a rib at the back of the next lower one. Alternate beams are placed opposite one another, and each set can be slid past the other, the peculiar connecting joints being able to slide past the fulcra and the pans on each beam. To solve an equation the coefficient weights are placed in their pans, and the two sets of beams are made to slide past one another. At certain positions the beams change the direction of inclination. These positions of balance are noted on a scale, the readings of which are roots of the equation. When there are not more than two impossible roots the machine will find them; for this purpose the real roots are first found and divided out, the resulting quadrate being placed on the machine. Instead of a change of inclination of the beams a maximum or minimum of pressure is observed by a spring balance. The reading of the scale is then the real part of the root, and the square root of the pressure the impossible part.

Mr. A. Hilger exhibited and described a new driving clockwork of isochronous motion, regulated by a fan-governor, and a new direct vision spectroscope.

LEGAL.

The Provincial (Brush) Electric Light and Power Company v. Shillingford and Bateman.

This case was continued on Friday last, and at its conclusion the learned judge said that the question he was asked to determine was so novel that he would take time to consider it. The action was to enforce the payment of a sum of £53 odd, which the plaintiffs alleged was due to them as the balance of their account with the defendants under a contract between them and the defendants for the installation of the electric light at the defendants' brewery, at Whitney, in Oxfordshire. The defendants, who had paid the plaintiffs £100 of their account, defended the action on the ground that in the contract the plaintiffs had guaranteed their light would be a success, whereas, it was alleged, it had resulted in a complete failure. They also counter-claimed to have £50 of the £100 already paid to the defendants returned, on the ground that it was money paid by mistake of fact, viz., under the belief that the light would ultimately succeed; and they also claimed a sum of £50 as damages for the loss of the expected advantages of the electric light. The plaintiffs admitted that, as a fact, the light had failed, but pleaded that the failure was due to the defendants' own engineer.

Mr. F. King, the acting engineer to the plaintiffs, stated that on examination he found the dynamos in all their parts perfectly satisfactory. The accumulators, he admitted were standing upon iron rods; but that, in his opinion, did not matter, and would not cause leakage of the acid, as had been suggested, because the jars were of stoneware, and the wooden separators having been boiled in paraffin wax, no capilliary attraction could take place. In his opinion the filaments of the lamps were broken by too strong a current, which might be the result of over running, or of running the engine at the same time as the accumulators were being charged. This was shown, he said, by the discoloration of the glass of the lamps in question. The glass would not blacken if the filaments had broken through faulty construction. It was stated that King and Thomson had instructed the defendants' man Baker, who, it was admitted, knew little or nothing of electricity, how to conduct the lighting, and that he was never to permit a greater current than 25 amperes, which the ammeter would show him. It was suggested by the plaintiffs that Baker had neglected these instructions, but no direct evidence of this could be adduced, and the plaintiffs based their contention on the facts, viz., broken filaments with blackening of the glass, frequent melting of the safety fuses and rapid wearing away of the brushes, together with damage to the dynamo. Baker, on the other hand, was called, and produced his instructions, which he swore he had invariably adhered to. It was admitted by the plaintiffs that they had guaranteed a success, which they alleged they had effected so far as they were concerned, and in support of this contention they referred to the lengthy correspondence in the case, commenting on the fact that from the time when the defendants took over the installation, about the end of Sept., 1884, down to Oct. 20, no complaint had been made; and further, that in a letter of Oct. 16 the defendants had said that the light was working fairly well, and on Oct. 20, "Not so good as when started." On Nov. 3 the plaintiffs had sent in their account, viz., £145 odd. This correspondence, however, it should be mentioned, showed that during all this time there were frequent little details going wrong. In answer to the plaintiffs' account, the defendants on Nov. 10 wrote that they would send a cheque as soon as the light worked satisfactorily; and on Dec. 16 the defendants sent the plaintiffs a cheque for £100. This fact was urged by the plaintiffs as an admission that the lighting had succeeded when coupled with their (the defendants') letter of Nov. 10. The dynamo was returned for repair to the plaintiffs on Feb. 6, and shortly after that the whole thing was given up, and in the result the present action was brought, as the defendants refused to pay anything further in respect of the installation. The defendants' case was that from first to last the light had been a failure, for they had understood, it was stated, that the system of storage would have given them a constant light for 10 lamps all night, whereas their manager, who was called, stated that with only 6 lamps running, the light would only last 4 or 5 hours, and with more not 4 hours. He also stated that they (the defendants) had been obliged to supplement the electric light with gas, and that at 6 a.m., when brewing, the light had never been available, and often began to fail at 9 p.m. They also alleged as regarded the electrical plant that—1st, cells of the accumulators insufficient for holding acid; 2nd, brushes wearing out; 3rd, filaments of bad construction; 4th, insufficient connections between the different lamps; 5th, life of lamps too short; 6th, fuses and cut-outs carelessly adjusted; 7th, accumulators insufficient.

In the end, the learned judge declined to go into a great deal of the scientific evidence, remarking that, as he was not an electrician, it would to him be perplexing, ambiguous, and misleading, and he intended to decide the case upon the broad question, regarded from a common sense point of view. His Lordship deferred judgment.

Electrical Power Storage Company v. Elwell-Parker.

In the Chancery Division, on Friday last, before Vice-Chancellor Bacon, Mr. J. C. Graham appeared in an action for an injunction to restrain the infringement of a patent. The case was mentioned in July by the Attorney-General. Since then the defendant had submitted to an injunction, and he (Mr. Graham) was instructed to move for judgment for an injunction during the continuance of the patent.

Mr. INGLE JOYCE said the defendant consented to an order for an injunction to restrain the infringement of the patent; no costs to be granted on either side.

The VICE-CHANCELLOR made the order asked.

The Hydro-Carbon Syndicate (Limited).

In the Chancery Division, on Saturday last, before Mr. Justice Chitty, Mr. Ince, Q.C., appeared in support of a petition by this company for a voluntary winding up under supervision. The company purchased certain electric patents, which did not turn out well; but in the course of the experiments with those patents they discovered other matters which were valuable. The winding up was with a view of the formation of another company, the present company having spent all its capital, and it had been resolved upon by resolution of a general meeting of the shareholders. There was no opposition.

Counsel for shareholders and creditors stated that they did not oppose the petition.

The JUDGE: Do you say there is a surplus?

Mr. INCE: Oh, yes.

The Judge granted the order asked.

COMPANIES' MEETINGS.

Blackpool Electric Tramway Company.

The first annual meeting of shareholders of this Company was held at the offices, Blundell-street, on Saturday afternoon last, Mr. Alderman Richard Horsfall (Mayor of Halifax), Chairman of the Company, presiding.

The SECRETARY (Mr. R. Handley) read the report of the Directors.

The CHAIRMAN moved the adoption of the report and balance-sheet as circulated.

Mr. BANNISTER (Manchester) seconded.

Dr. KINSBURY said that before the balance-sheet was approved of he and other shareholders would like to have some information on several of the items which he thought required some explanation. Under the head "Capital and Liabilities" he saw that there was owing for cars, balance of contract, £140; he would like to have some little information upon that. The next item read "Travelling, hotel, and other expenses, joiners' work, electrical fittings, &c., £171. 16s. 11d." He thought it only fair to the shareholders that that amount should be differentiated, the different items put separately. Items so heterogeneous as hotel expenses and electrical fittings should not be grouped together. The £888 owing to the Preston Bank he supposed would be only an ordinary overdraft. Then there was a *nota bene* to the effect that there were other liabilities, approximated at £2,000, the amount of which had not yet been eventually settled or ascertained. He considered that very unsatisfactory—they might be owing £15,000 as far as the shareholders were able to say. In the property, assets, and preliminary expenses there were several items which required explanation. The first item was £1,000, on account, to the contractor for building the tram shed. He would like to know what was the balance owing, and who was the contractor. Another item was "architects, £60 on account." Surely, it did not take two architects to construct or plan that shed. How much balance was owing? For generators, motors, £500 had been paid on account. He wanted to know what was still owing, whether the motors were working satisfactorily, or whether any cost would be incurred by the Company in replacing them if they did not. In connection with the

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centre channel he saw that £4,000 odd had been paid on account for electrical fittings. It was a very large item to pay on account, there might be another £4,000 owing, so that he wanted some information. The contractor had received £600 on account of laying the centre channel—how much more was to pay? The next items was "Mr. M. H. Smith on account of consideration for the assignment of the Corporation concession and patent right for Blackpool, £500; engineer's commission, on account, £400." He supposed the £500 would be under the original agreement, but he could not understand the £400 for engineer's commission. What was the balance due, and under what agreement was the amount paid? Under the head preliminary expenses there was the item "travelling, hotel, and other expenses, £213. 16s. 4d." He wished to know what was the relation between that item and the item of £171 in the capital and liabilities account. He thought the balance-sheet most unsatisfactory—he had never seen a balance-sheet so skilfully designed as to leave the owner of it in a state of ignorance as to the real facts of the case. He would move that it be referred back to the directors in order that it might be so prepared as to show on the face of it in what sum the Company was already indebted.

The CHAIRMAN said thst he was glad that Dr. Kingsbury had taken the interest he had in dissecting the balance-sheet. Of course at a first meeting it was a difficult if not an impossible matter to furnish a true and correct statement of liabilities. He thought the *nota bene* explained itself. In addition to the liabilities shown on the balance-sheet there were others estimated at £2,000. £1,800 had been paid the contractor, Mr. Cardwell, but since the accounts had been prepared the balance had been ascertained to be £348, and he had been paid that sum. They had a contract with Elwell, Parker, and Co. for motors. Some had been supplied and some had not. The earlier ones supplied did not work satisfactorily, but since then alterations had been made, and the motors were now working exceedingly well and most satisfactorily. They had been paid a certain sum on account, and the balance due to them when they had completed their contract would be, he thought, about £700. There was a balance due to Smith, Baker, and Co. for electrical fittings of £400, as near as they could ascertain. On the accounts sent in by Mr. Copley, the contractor, there was a balance due of £210, but that they expected to reduce. The balance due to the engineer was about £100, and instead of being £2,000 as approximated on the balance-sheet he thought their total debts would amount to about £1,700. He thought that statement would explain all questions that Dr. Kingsbury had raised with respect to payments on account.

Mr. R. HANDLEY read the various items which made up the £171 classified as travelling and other expenses. The Directors' expenses out of pocket amounted to £42, and the rest was made up of payments for electrical fittings, joiners' work, printing, &c. The item of £213 under the same head on the assets side included expenditure, which had been actually paid, and items which had not been paid. The £171 was all outstanding; it had not been paid.

The CHAIRMAN said that the balance owing for architect's fees was about £40. He did not know exactly. In answer to questions as to the motors, he said that those first sent by Elwell, Parker, and Co., did not answer, but they had now got an improved motor, which was most efficient. Their contract with Elwell and Parker was most stringent, and the Company would not suffer any loss because of the failure of the first motors supplied. The travelling expenses of the ten Directors during the twelve months did not average more than £4 each. They had charged for nothing except bare expenses out of pocket. £400 had been paid Mr. M. H. Smith as his commission—5 per cent. upon the electrical work of the central channel, and 2½ per cent. upon the engine and cars. There was still about £100 owing him.

Dr. KINGSBURY said he would be sorry to make any objection, but how did they come to pay Mr. M. H. Smith anything at all for commission? He had never seen anything mentioned as to Mr. Smith receiving a special commission.

The CHAIRMAN said that he was rather surprised to hear a gentleman in Dr. Kingsbury's position raise a question of that kind. Mr. Holroyd Smith had been a resident in Blackpool nearly all the summer. They had had two or three assistants who had been carrying out the work, and of course he had them to pay. Surely if they engaged an engineer to construct works they must pay him for the labour and time he spent upon them. He knew that Mr. Smith was not satisfied with the way in which the Directors had pulled up his accounts and cut down his commission, but still they had their duty to the shareholders to consider.

Mr. E. DEAN said that he had not seen the agreement which had been entered into between the company and Mr. Smith. He wished to know if the £2,000 was to be paid to Mr. Smith irrespective of whether his mode of working the line was successful or not. As he understood it, new motors were rendered necessary because of the failure of the proposed system of working the cars.

The CHAIRMAN said that Mr. Dean was under a misconception. The failure of the first motors supplied by Elwell, Parker, and Co., was due to a delicate bit of machinery which gave way. They were not constructed according to Mr. Smith's specification—Elwell and Parker thought they had a better idea, but it had turned out a failure. The motors were reconstructed in accordance with Mr. Smith's instructions, and they were working successfully. The Company would be to no cost on account of the experiment of Ewell, Parker and Co.

In answer to Dr. Kingsbury, the CHAIRMAN said that they, the Directors, agreed with Mr. Smith to pay him engineer's commission on the works, in order that he would give special attention to it.

In answer to Mr. Deacon (Bolton), the CHAIRMAN said that they would have to pay Mr. Smith the amount agreed upon for his patent right, whether his system was a partial or a total failure. On the other hand, however, they did not admit that it would be a failure—they were very well satisfied that it would not be a failure. In reply to another question the Chairman said it was not true that the Corporation and that Company were at great variance. He was glad to say that they were working very harmoniously together—the Corporation was meeting them in every possible way they could. The delay had arisen partly from difficulties the Corporation had experienced, and they were partly to blame as well.

Ultimately the adoption of the balance-sheet was agreed to.

The CHAIRMAN said the retiring Directors were Messrs. Bickerstaffe, Broadbent, and himself. Mr. Hyde had given notice that he intended to propose the appointment of Dr. G. C. Kingsbury as a Director. That morning, however, the Directors had received the resignation of Dr. Scholefield, of South Shore, and they recommended the appointment of Dr. Kingsbury in his place.

Mr. HYDE said in that case he would propose the re election of the three retiring gentlemen, and the election of Dr. Kingsbury in the place of Dr. Scholefield.

The motion was seconded and agreed to.

Messrs. J. D. Taylor and Co., Halifax, were re-appointed auditors to the Company.

Mr. HYDE said that a question which had been giving him much anxiety of late was as to the rights of renewal the Company had at the end of seven years.

The CHAIRMAN said that if the Corporation decided to purchase their electrical plant, and themselves to work the line, they had to give them notice in writing within the first three months of the last year of the term of seven years for which it was leased to them. If the Corporation failed to give notice the Company would give notice within the second three months of the last year, requiring a continuation of the terms of the lease for another seven years. The same proceedings would take place at the end of 14 years, and at the end of 21 years the power of the Corporation to buy the electrical plant would expire. He (the Chairman) thought that it was a most satisfactory agreement.

The proceedings concluded with a vote of thanks to the Chairman, who expressed the hope that at their next meeting they would be able to declare a satisfactory dividend.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Dec. 9.		Business Done Week Ending Dec. 9. Highest.	Lowest.
Anglo-American	31½,	32¼	32½	31¾
Do. Preferred	53,	54	53¾	52¾
Do. Deferred	9½,	10½	9 15-16	9½
Brazilian Submarine	10⅝,	10⅞	10⅞	10¾
Cuba	11,	11½	11½	11
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9¼,	9½	9 15-16	9⅛
Eastern Telegraph	11⅛,	11¾	11⅞	11⅛
Do. 6 per Cent. Preference	13½,	14	—	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12¾,	13	13	12¾
German Union	9½,	10	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7⅛	6 15-16
Do. Preference	13¼,	13½	13½	13¼
Great Northern	13⅞,	14⅛	14 1-16	13 15-16
Indo-European	32,	33	32¾	31¾
Reuter's	7,	7½	—	—
Submarine	205,	215	—	—
West India and Panama	¾,	1	¾	—
Do. 1st Preference	8,	8½	8½	8¼
Western Brazilian	5⅜,	5⅞	5⅞	—
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅞,	1	15-16	—
Oriental	3-16,	5-16	—	—
United Telephone	12½,	13	12¾	12⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3,	3½	3¼	2 13-16
Do. (fully paid)	4¾,	5¼	5⅛	4⅞
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1,	1¼	—	—
Maxim-Weston	¼,	⅜	—	—

MISCELLANEOUS.

Telegraph Construction	36½,	37	37	36½
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24⅞	24½

TRAFFIC RECEIPTS FOR NOVEMBER, 1885.

Companies.	Nov., 1885.	Nov., 1884.	Increase.	Decrease.
Cuba Submarine	2,250	2,326	—	76
Direct Spanish Telegraph	2,021	1,729	292	—
Eastern Extension	40,427	42,286	—	1,859
Eastern Telegraph	56,245	55,640	605	—
Great Northern	22,800	—	—	—
West Coast of America	3,775	—	—	—

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NOTES.

THE EARTHQUAKES IN ALGERIA.—Another shock of earthquake has been felt in the Msila district of Algeria.

THE ELECTRIC LIGHT IN BRAZIL.—An installation of the electric light has been put down at Rio Claro, Brazil.

THE ELECTRIC LIGHT AND MINES.—The works of the Alice Mining Company, Silver Bow County, Montana, are now electrically lighted.

THE TELECTROSCOPE.—Such is the name of the electrical instrument of the future, by means of which we are to see at an infinite distance.

SELF DECORATION.—Electric shirt studs containing a small incandescent, fed of course by a pocket accumulator, are among the latest novelties.

STRUCK BY LIGHTNING.—Mr. Skinner, a conductor in the Commissariat Department, and his son, have been killed by lightning at Jubbulpore.

BURMAH.—All telegrams referring to the condition of the upper province are subjected to the censorship of the military authorities at Thayetmyo.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 11th inst., amounted to £2,931.

A COURSE OF LECTURES.—We are informed that M. Bouty has opened a course of lectures at the Collège de France, Paris, on the "Mechanical Theory of Heat, Magnetism, and Electricity."

OBITUARY.—We regret to hear of the death of Mr. Henderson, Chairman of the India Rubber, Gutta Percha, and Telegraph Works Company. The funeral took place yesterday (Thursday).

THE TELEPHONE AND THE ADMIRALTY.—Experiments are about to be made at Portsmouth with the view of extending the use of the telephone in the dockyard, the electric shop being the central exchange.

THE SOUDAN TELEGRAPHS.—A telegram from Wady Halfa states that the telegraph to Kosheh is open.—The telegraph line south of Akasheh is cut, but heliographic communication has been established.

RIPON.—It is proposed to build a new public hall at Ripon. The artificial lighting has not been decided upon, in view of the suggestions made by members of the Corporation to adopt the electric light in the city.

THE GREAT FIRE IN SOUTHWARK.—In connection with the great fire which broke out recently in Southwark, it is stated that the heat of the flames was so intense as to cause some telegraph wires to fall into the street.

H.M.S. "COMUS."—Orders have been received at Sheerness port directing the "Comus," 14, unarmoured screw corvette, 2,380 tons, 2,450 horse-power, attached to the Fourth Division of the Medway Steam Reserve, to be fitted with the electric light.

THE WHARVES OF NEW YORK.—Visitors to New York City should pay a visit to the river front. Along the North and East Rivers and the Battery is an almost continuous chain of arc lights, which thoroughly and effectually illumines the wharf line.

EDISON'S LATEST.—Mr. Edison, having found the cares of business to weigh far too heavily upon him, has finally decided that in his case a partnership offers many advantages. He is about to be married, and to an interesting and accomplished young lady.

THE TELEPHONE IN SPAIN.—It has been decided that on and after the 1st of January, 1886, the quota of subscription for each of the telephone exchanges mentioned in Articles 7 and 8 of the law of the 12th of August, 1884, shall be 300 pesetas per annum.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 11th December were £2,252, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

A NEW CATALOGUE.—We have received a large and well illustrated catalogue of the manufactures of the Brush Electric Company of Cleveland, Ohio, U.S.A., giving a full and clear description of the various apparatus entering into the Brush Electric Lighting system.

THE PERSIAN TELEGRAPHS.—Advices from Teheran state that a Convention has been concluded with the Persian Government whereby the English are to assume the temporary management and maintenance of the Meshed telegraph, which is greatly in need of overhauling.

BIEN BON MARCHE.—An electric lighting company in Germany, who have acquired the rights in that country of the Ganz transformateurs, gravely announces that installations upon this system are *several hundred times* cheaper than upon any other system in existence.

DOMESTIC LIGHTING.—We are pleased to be able to announce that Aldenham Park, Bridgnorth, is to be partially lighted with the electric light. Mr. F. Geere Howard, of Cleveland-street, W., a gentleman well-known to many of our readers, has been entrusted with the carrying out of the work.

BOOKS RECEIVED.—"Notions Générales sur l'éclairage Electrique," par Henry Vivarez; second edition. Paris, J. Michelet. —"Dynamo-Electric Machinery: A Manual for Students of Electrotechnics," by Silvanus P. Thompson, D.Sc., B.A.; second edition, enlarged and revised. London, E. and F. N. Spon.

THE ELECTRIC LIGHT IN CHICAGO, U.S.A.—The contract for extending the electric light system in the Government building in Chicago was let November 13th to the United States Company, at 8,500 dollars. One hundred and twenty-five 16 candle-power lights and twenty-five 150 candle-power lights will be put in.

IN THE ORGANIC WORLD.—The distribution of electrical force in living organisms is a subject that calls aloud for investigation. We have an electric plant, an electric bug, an electric slug, and three electric fishes, to say nothing of the electrical systems of all animals. About these things we know just next to nothing.

THE AFFAIRS OF OPPERMANN BROS.—We learn from the *London Gazette* that the trustees appointed by the High Court of Justice in Bankruptcy, in the Matter of Oppermann Brothers (in liquidation), are Henry Alabaster, of 22, Paternoster-row, E.C., and Charles Henry Walker Biggs, of 1, Salisbury-court, E.C.

RECKENZAUN'S ELECTRIC TRAM CAR.—We learn from our Berlin correspondent that the first trials of this car on the line Brandenburger Thor-Moabit-Ausstellungspark took place a few days ago in the presence of the directors of the Berlin Tramways Company and of the Municipal authorities. The trial was a perfect success.

ELECTRICITY AND MINES.—The Zankerode Mine at Plauen, near Desden, has an electric railway, the coal being conveyed

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700 to 800 yards by one of Siemens and Halske's electric locomotives. The distance is traversed in about four minutes, and the journey is made fifteen times a day, during which time about 200 tons are transported.

THE TELEGRAPH BATTALION.—Official orders were received at Aldershot on the 14th inst. for Lieutenant Frederick Gilbert Bowles, eighteen sergeants, corporals, and sappers of the Telegraph Battalion Royal Engineers, to proceed to Portsmouth forthwith and embark for special service in Egypt. They left Portsmouth on the 16th inst.

EASTERN EXTENSION, AUSTRALASIA AND CHINA TELEGRAPH CO.—This company notify that the coupon on their 5 per cent. Australian Government Subsidy Debentures, due on the 1st January next, will be paid on and after that date at Messrs. Barclay, Bevan and Co., 54, Lombard-street. Coupons must be left three clear days for examination.

TELEGRAPH POLES.—We are informed that the tenders of the following firms have been accepted for the supply of next year's telegraph poles to the Postmaster-General:—For delivery in London: Mr. E. Rasmussen, Porsgrund, Norway. For delivery on the Tyne and at Perth: Messrs. Calder and Co., Glasgow. The tenders for creosoting have not yet been decided.

A NEW USE FOR THE TELEPHONE.—The *Metropolitan* says that the sick chamber may be enlivened by using a very clever adaptation of the telephone which Messrs. Cordner, Allen and Co. have invented. It is inexpensive, readily adjusted, and conveys the faintest whisper. The *Lancet* gives a very favourable account of it, and recommends the invention to the special attention of surgeons and others.

THE LATE SIR WILLIAM SIEMENS.—A biography of the late Sir W. Siemens is being prepared, at the desire of the executors, by Dr. William Pole, F.R.S., honorary secretary of the Institution of Civil Engineers, and author of the life of Sir William Fairbairn. Dr. Pole will be grateful for the loan of any of Sir William's letters, or for any information of importance. Address Athenæum Club.

THE TELEPHONE IN SWEDEN.—It is stated that Princess Victoria of Sweden has had the telephone installed between her residence and the royal chapel in the castle, as her health does not always permit of her leaving the house to attend Divine worship. Receivers are placed in various parts of the chapel, and the sound is transmitted very satisfactorily, so that the princess is enabled to follow and enjoy the service.

ELECTRO-DEPOSITION.—The admirable work, by Dr. Gore, entitled "Theory and Practice of Electro-Deposition;" including every known mode of depositing metals, preparing metals for immersion, taking moulds, and rendering them conducting, has been revised by a competent authority, and will be republished early next year. We advise all of our readers to secure a copy, as it is the best book by far that has ever been written upon this subject.

THE ALARMING FIRE AT LEEDS.—Notwithstanding the most energetic and prompt efforts of the fire brigades, the fire which broke out in the chemistry lecture-hall at the Yorkshire College at Leeds on Monday night continued for nearly four hours. The damage is estimated at nearly £3,000. The fire was apparently caused by the heat given off from two ordinary sunlights similar to those in use at most of the public buildings in Leeds and other large towns.

A NEW ASSOCIATION.—The old students of the Ecole de Physique et de Chimie Industrielles de la Ville de Paris are about to found a society under the title of "Association Amicale des Anciens élèves de l'Ecole de Physique et de Chimie," with the object of promoting amicable relations between workers in these branches of science, and to furnish them with aid where necessary to enable them to carry on their studies, exploit their inventions, or protect their interests

FOOD FOR THOUGHT.—One of the most attractive of the sciences, and one with which we have necessarily much in common, is chemistry. We know of nothing more refreshing after a hard day's work than to relax the mind with a dreamy reflection upon, say, the derivatives of Metanitrobenzenylamidoxime and Metanitrobenzylazoximebenzenyl, or upon the properties of Phenoxydiphenylmethylphosphonium iodide $PMe\ Ph_2\ I.\ OPh$; the OPh being kept prominently in view. Truly we have much to be thankful for.

LOCAL BILLS IN PARLIAMENT.—Among the local Bills to be brought forward during the coming parliamentary session we notice one relating to the Keighley, Bingley, Shipley, and Charlestown Extension Tramways. New lines are proposed by this Bill to be laid down in the districts of Bradford, Shipley, Bingley, Keighley, and Charlestown, and extensions of existing lines are provided for. The promoters also ask to be authorised to use steam, electric, or other power, and to hold and acquire patent and other rights in relation to such power.

MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.—During the course of his inaugural address, the president of this institute, at a meeting recently held, made reference to the application of electricity to various mining purposes, and bore testimony to the usefulness of the electric signal, and the light on the pit bank. There was no doubt that in the not distant future electricity would play a very important part in the working of collieries. A discussion afterwards took place on Mr. Sydney F. Walker's paper "On Improvements in Electric Signalling in Mines."

LIGHTING OF SANDYCROFT FOUNDRY.—The works of the Sandycroft Foundry and Engine Works Company, near Hawarden, have just been fitted up with the electric light by the Maxim-Weston Electric Company. An exhibition of the light was given on the 11th inst., in the presence of a distinguished company. The lights were run for two hours, under the superintendence of Mr. J. J. Tough, works manager to the Maxim-Weston Company, and gave a beautiful, bright, and steady light, which the various superintendents at Sandycroft considered all that could be desired.

GERMAN CABLES.—It is well known that of recent years Germany has been busy in putting long lengths of her telegraph wire underground. The type of cable usually used is a seven strand copper, each insulated with gutta percha. The copper weighs 90lb. to the mile, the gutta percha 76lb The insulated wires are protected with 24 galvanised iron wires, weighing about 4,080lb. per mile, over which is a serving of jute soaked in bituminous compounds. The cable as a whole weighs about 6,100lb. per mile, and has a breaking strain of 4·5 tons. The cables are mostly buried without other protection.

CAOUTCHOUC IN WATER.—Water has no solvent action upon caoutchouc, but by long boiling in this liquid it swells to some extent, in which state it is affected by some solvents with greater facility than in its ordinary condition. Exposed to the air it resumes after a time its usual form, but the desication takes place very slowly. It has been seen that when a sheet of the best masticated rubber is exposed in water, open to the air in diffused light, it will absorb something like 90 per cent of water, and finally become white, opaque, slimy,

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and sticky. In sea water under the same conditions, its absorption of water is almost *nil*.

THE TELEPHONE AT BOURNEMOUTH.—At a recent meeting of the Bournemouth Improvement Commissioners the Roads Committee reported that the manager and engineer of the Western Counties and South Wales Telephone Company had explained to them the system they proposed for telephone exchange in Bournemouth. The committee saw no objection to the system proposed. Mr. Hutchings objected to the telephone wires being allowed to be above ground, pointing out that they had just asked the Post Office authorities to put their wires underground. Mr. Fisher said they ought not to throw objections in the way of the introduction of a system which would be so obviously for the benefit of the town.

THE ELECTRIC LIGHT IN BLACKPOOL.—The Directors of the Blackpool Winter Gardens and Pavilion Company have decided to illuminate their gardens, fernery, and floral halls during the ensuing season with the electric light; and have appointed a committee to make inquiries as to the best systems, and to report to the Board. These gardens are visited by over 600,000 persons annually from the busy hives of industry in the neighbouring counties of Lancashire and Yorkshire; and the buildings being so admirably adapted for the purpose, it is intended to make the installation an exhibition of all the latest developments and improvements in electric lighting.

THE ELECTRIC LIGHT AND THE SUEZ CANAL.—A telegram from Alexandria says that the new regulations by which steamers with electric lights are allowed to pass through a portion of the Suez Canal at night is a gain of infinite importance. The new regulations laid down by the Canal Company are to the effect that all vessels desirous of navigating the canal at night between Port Said and Kilometre 54, and *vice versâ*, shall carry at the bows an electric projector, throwing a ray to a distance of 1,200 metres, and at the stern an electric lamp capable of illuminating a circle of from 200 to 300 metres in diameter. In addition to these two, electric sidelights must be carried.

THE TELEPHONE IN MINES.—In connection with our note of the 11th inst. on the telephone in mines, we are informed that the instruments offered by the Northern District Telephone Company were specially designed, at the suggestion of Mr. C. B. Clay, of the above company, by Mr. G. A. Mason, of the Consolidated Telephone Construction and Maintenance Company. The set for the mine is composed of a Bell receiver, Blake transmitter, magneto ringer, and generator. The latter is in an air-tight compartment, to prevent any possibility of explosion of fire-damp by sparking. The whole set is contained in a portable box about 18in. square. The great advantage of a magneto call for mining purposes is that the ringer, which must necessarily be open, never sparks.

AMERICAN ITEMS.—The Decatur, Ill., Gas Committee has agreed upon the terms of a contract for tower electric lighting with the Fort Wayne Jenny Electric Light Company.—An experimental electric railway has been laid on Ridge Avenue, Philadelphia, from the depot of the Ridge Avenue line of cars, about three-quarters of a mile out, and the first trial was made during the past week. The car was run over the track, and the officers of the company declared that everything was working to their complete satisfaction.—The *Milwaukee Sentinel* says that a long-distance transmitter is being tested in the local office of the Wisconsin Telephone Company, the same used in the attempt to converse between Chicago and New York. By using the new transmitter a whisper can be heard a distance of 250 miles with the same distinctness that it can by a person in the same room. The telephone company has made a requisition for a number of the instruments, and they will be used on all of the long-distance lines.

THE ELECTRIC LIGHT AND BUILDERS.—On the night of Thursday last a noteworthy instance of enterprise in the building trade was afforded by Messrs. Bradney and Co., Wolverhampton, who are engaged, under a contract, upon the erection of a large theatre at Derby. The building was only begun on the 2nd November; and as it is intended to open the place early in March, Messrs. Bradney have resolved to secure further time by placing an electric light at each of the four corners of the structure, so enabling the bricklayers and carpenters to carry on their work with almost the same facility as during the day. On Thursday only one light was used, but as soon as the whole of the arrangements are complete, the whole of the men will be able to work the entire night through. The engine which grinds the mortar is employed to supply the necessary power; and to further facilitate work, bricks warm from the kiln are used to counteract the effect of the frost. By the adoption of this expedient the severe weather of the last week has been set at defiance.

THE TELEPHONE AND THE QUEEN OF THE BELGIANS.—It is well known that the Queen of the Belgians has for a long time possessed a telephonic installation (on the Van Rysselberghe system) between her Palace of Laeken and La Monnaie Opera House. The other day the company were going through the score of the "Templiers," the new opera by Litolff, which is to be performed for the first time in Brussels. Her Majesty was listening to a magnificent duet in the piece, where the children of Philippe le Bel and Enguerand de Marigny reveal their love for each other, when all of a sudden the telephone dropped from her hands. The talented leader of the orchestra, M. Dupont, finding occasion to admonish the chorus singers, had invoked the name of the Deity in a manner altogether foreign to courtly etiquette. The Queen made a formal complaint, and since that time everything has gone wrong at the opera house. Litolff threatens to retake his MS., and the managers of the theatre also threaten the cancelment of their contract. Beyond all this, the subscribers, now aware that the slightest word they utter will reach the royal ears, have abandoned the green room and wings *en masse*; a very good thing, we should say, for the management.

THE FIRST TELEPHONE IN ARABIA FELIX.—By this time no doubt the gentle Arab is fairly conversant with the telephone, but the case was different when, some half dozen years ago, two of our readers paid a visit to the Sultan of Lahej, at Al Hautah, in the province of Yemen. As a propitiatory offering to the Chief, they took with them a pair of telephones and about a hundred yards of wire, which they ran up between the courtyard of the Mud Palace and the Council Chamber, in which latter some twenty headmen were squatting in company with their master. The first whisper that came through the telephone had the effect of sending them all scuttling away like a swarm of land crabs on the approach of an invader; but they were eventually soothed and brought back again. The sultan, at first highly interested in the "little foreign talking devil," at length grew tired, and complained that it did not speak Arabic. He was assured that it spoke all languages, and in proof thereof a polyglot individual was taken to the other end of the line and made to chant the praises of his Highness in a crescendo, which ran the gamut of the thirty-nine dialects of Arabia. Before, however, the telephone had a chance of properly vindicating its character the Council Chamber was cleared; even the dignity of the Sultan being unable to withstand *too* much magic.

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HONOURS.—At a meeting on Tuesday of the Senate of Dublin University, it was resolved to confer the degree of LL.D. (Honoris Causâ) on the Right Hon. Baron Rayleigh, late Professor of Experimental Physics in the University of Cambridge, and now one of the Secretaries of the Royal Society; and on W. Huggins, F.R.S. Dr. Ingram, in submitting the graces as Senior Proctor, said the first name was that of Lord Rayleigh, who devoted himself at first to the study of pure mathematics, in which he became highly distinguished. He afterwards used the skill thus acquired as an instrument of physical research. He has specially studied the subjects of sound and light, was lately professor of experimental physics in the University of Cambridge, and was now one of the secretaries of the Royal Society. Lord Rayleigh was President of the British Association for the Advancement of Science at its meeting in Montreal in 1884. The second name recommended by the Chancellor was that of William Huggins. Mr. Huggins early threw himself with ardour into the line of investigation opened by Kirchhoff and Bunsen—that of chemical analysis. Mr. Huggins had obtained for his researches the gold medal of the Royal Astronomical Society, and had twice been presented with medals by the Royal Society. He has also been awarded the Lalande prize for astronomy by the French Academy of Science, which had elected him one of its corresponding members.

THE ELECTRIC LIGHT AND HEALTH.—At the Parkes Museum of Hygiene, in Margaret-street, Oxford-street, recently, Mr. Eric S. Bruce delivered a lecture on "Health and the Electric Light," Sir Joseph Fayrer presiding. The lecturer stated that the requirements of an artificial light, in order to make it conducive to health, were that it should not be a source of impurity to the atmosphere; it should heat the atmosphere as little as possible; it should be a brilliant bright light, and should be perfectly steady, cleanly, and in no way a danger. Most of those requirements, however, were not met by the forms of artificial light in use; indeed, all lights which were dependent on combustion at the burner were sources of impurity to the atmosphere, and a danger to the public. The electric incandescent lamp, he pointed out, was the only light where they had perfect incandescence without appreciable combustion in the lamp. It possessed all the health requirements of an artificial light, such as an inappreciable heat, purity and brilliancy of colour, steadiness of light, and immunity from danger of fire. The lecturer having shown by experiments the advantages of electric lighting over other illuminants, concluded by tracing the present depression in the electrical market to the experimental nature of the earlier work, the prejudices of the public, and certain drawbacks of the present Electric Lighting Act. At the conclusion of the lecture the chairman, in moving a vote of thanks to Mr. Eric Bruce, said the electric light possessed almost every advantage that was required in an artificial light, and in his opinion it was destined to be the light of the future.

THE ELECTRIC LIGHTING ACT.—At the annual general meeting of the Society of Telegraph-Engineers and Electricians yesterday week, the council reported that they had unanimously passed the following resolution in reference to the Electric Lighting Act, and forwarded a copy thereof to the President of the Board of Trade:—"Resolved unanimously, that the Society of Telegraph-Engineers and Electricians have seen with regret that since the passing of the Electric Lighting Act of 1882 public lighting by electricity has not made that advance in this country which was confidently anticipated, and hence there has not been that stimulus to progress in many branches of electrical science that might have been anticipated, judging from the history of submarine telegraphy. That the society, having had the matter under careful consideration, have come to the conclusion that the restrictions in the Electric Lighting Act have in a great measure contributed to check the advance of public lighting by electricity; and they venture to request the President of the Board of Trade to consider whether these restrictions might not be modified or removed." The council were aware that equally strong representations upon the subject were made to the Board of Trade from other quarters; and they confidently hoped that in the next Parliament the matter would obtain that attention which it deserved, and that some amendments in the Act would be made to render it a help rather than an obstruction, as it was at the present time, to the development of public and domestic lighting by electricity.—The *Pall Mall Gazette* says:—"There are few who will watch with more anxiety the solution of the political problem than those who are interested in electric lighting. Mr. Chamberlain's Act practically put an extinguisher upon the development of that industry by its stringent compulsory purchase clause. That Act has to be amended in the coming session. Electricians would like to be placed upon the same footing as gas companies, free from the threat of compulsory purchase, but they are not likely to get those terms from either party. Lord Salisbury, however, has let drop certain words of encouragement tending to show that he is in favour of affording much more encouragement to the new industry than it has ever yet received. Hence, if the Conservatives retain power, the developement of the electric light may enter upon a new lease of life. Such is the hope of many electricians."

THE ELECTRIC LIGHT IN THE LEEDS MUNICIPAL BUILDINGS.—The Free Public Library as well as a large part of the new Municipal Buildings have for the last two months been lighted by means of the new system of electricity supplied by Messrs. Paterson and Cooper, and a pretty accurate estimate can now be formed as to the measure of success which is likely to attend the new light. The projectors undertook to provide two dynamo machines capable of running 284 lights, each of 20 candle-power, and owing to some dispute which occurred between Messrs. Paterson and Cooper and the Leeds Corporation a good deal of interest has been taken in the system of lighting which is now being used. Sir F. Bramwell, who tested the machines previously to their being accepted by the Corporation, certified that they were quite capable of doing the work required of them. It is satisfactory to state that Sir Frederick's estimate has so far proved quite correct. The light burns with steadiness and brilliancy, and has proved thoroughly satisfactory to those who have to use it. Of course, it would be premature to say that the new dynamos are all that is claimed for them after the comparatively short trial they have had, but there is every reason to believe, judging from their past performance, that they will fulfil every requirement. A careful examination was made a day or two ago, and it was found that the machines were in perfect order, and providing a light which it would be difficult to excel. The Free Library officials speak in the highest terms of it, and it is in this department where the most severe test is made. It is several candle-power better than the last installation, and, at the same time it does not dazzle the eyes. The power is generated by means of two 12 horse-power gas engines fixed in the basement of the building. These engines are coupled, so that, should one of the dynamos get out of order, sufficient power could be generated from one machine to in a great measure compensate for the disabled one. The engines make about 180 revolutions per minute, and the dynamos 1,050 revolutions. Only eight lamps have had to be renewed in two months—a by no means large percentage. The lamps are the Alexandra, and

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give a light of exceptional steadiness and brilliancy of 100 volts. It may be mentioned that each dynamo machine is capable of giving an electrical output of 9,000 watts, equal to 142 lights of 20 candle-power, and of running twelve hours continuously without overheating. So far as can at present be judged, says a contemporary, the Corporation of Leeds have as good a system of electric lighting as there is in the country.

The Lighting of the City.—The following are the heads of the proposition made and (we understand) agreed to between the Commissioners of Sewers and the Anglo-American Brush Electric Light Corporation, dated the 12th November, 1885:—The company proposes to supply electric lighting to an area bounded on the north by Fleet-street, Ludgate-hill, St. Paul's-churchyard, Cheapside, Poultry, extending eastwards as far as the Royal Exchange, and bounded on the south by the whole length of Queen Victoria-street and the Victoria Embankment as far westwards as the City Boundary. The company to substitute electric lights for the existing gas lights in the main thoroughfares, and to use electric arc lamps of 2,000 candle-power each, to be placed not more than 60 yards apart, unless otherwise required by the commission. To maintain these lamps and keep them alight from sunset to sunrise at a cost of £26 each per annum. The existing arrangements for gas lighting are not to be disturbed, but to be left capable of being used if needed. Any expense incurred by the commission in consequence of the failure of the electric light is to be refunded by the company. The contract with the commission for public lighting to be in force for seven years, and the commission to have the right to renew the contract on the same terms for a further period of seven years, and also to have power to terminate the arrangement on certain terms to be mutually agreed upon. The company to have the right (but not the exclusive right) to supply electricity to all houses and public or private buildings and premises within the district, and to have free wayleave for their necessary works. The company to have the free use of the lamp-posts and subways under the control of the commission, and the commission is to give them every facility for carrying out the work. The company will extend the arc lighting to any of the other streets required by the commission, but the commission may continue the use of gas in those streets if it prefers doing so. The commission is not to incur any cost in respect of the installation of the works of the company. The *Daily News* understands that the report of the City engineer on this subject, submitted to the meeting of the Commissioners of Sewers on the 1st inst., is distinctly averse to the immediate adoption of lighting by electricity for street purposes. Colonel Haywood deprecates the proposal of the commissioners to undertake to supply electricity, since he considers it would at once bring them into competition with a rich and powerful company, able without much injury to its finances to reduce the price of gas one-half, and would by so doing frustrate the object of the commission in undertaking to supply an economical illuminant. The commission, in his opinion, would better further its ulterior object by exerting its influence to obtain a repeal of the the Electric Lighting Act, to which he attributes the existing stagnation of electrical enterprise in England.

An Electric Safety Lamp for Miners.—A meeting of the North of England Institute of Mining and Mechanical Engineers was held in the Wood Memorial Hall, Newcastle, on Saturday the 12th inst., when Mr. Joseph W. Swan exhibited portable electric safety lamps for miners, and said that at a meeting of the institute, four years ago, a form of lamp, which required a separate supply of electricity to be conveyed to it through a flexible cord enclosing two wires, was shown. A member of the institute criticised the feature of the dependence of the light on an extraneous supply of electric power, and expressed the opinion that the value of the electric light in mines would be greatly enhanced if the lamp and the supply of electricity to it could be combined in one apparatus. The apparatus now before them was a lamp and battery combined, capable of giving during ten or twelve hours twice or three times the light of a common safety lamp. On first lighting it gives the light of two candles, and after ten hours about one candle and a half. For regular mine working the cells were of lead and lead oxide. This kind of cell is a secondary cell Another kind of cell can be used, composed of zinc and lead oxide, with a special view to the occasional employment of the lamp for exploration in vitiated air. This is a primary cell, and only requires filling with liquid to make it ready to give light. It will sometimes be convenient to have a duplicate lamp within the bull's eye, with a switch connection to enable either, but not both, to be lighted, so that in case a lamp should fail the miner will not be left in the dark. The speaker had hoped to have been able to show a fourth modification, in which there are only two cells, instead of seven, to light a lamp. By this arrangement the weight is diminished to between 5lb. and 6lb. Believing that a good light was the most important point to be gained, after safety, the electric lamp shown had been to give two or three times the light of the ordinary lamps, and consequently it was heavier; in fact, weight was made subordinate to light. The apparatus could have been made much lighter if it had been permissible to employ a primary battery instead of a secondary one; but it appears to be only allowable to use a primary battery to meet sudden emergencies, and in those cases where there is no dynamo and no regular system in operation for charging secondary batteries. For mine exploration, where the air is very foul, as, for example, after an explosion, which has destroyed the ventilation of the mine, a lamp with a primary battery, in conjunction with a Fleuss breathing apparatus, will probably be found very useful. But as a substitute for the ordinary safety lamp for general underground lighting, a battery which requires, each time it is used, to have the spent charge emptied out, and a fresh charge poured in, and which also requires frequent renewal of the positive plate of each cell, is impracticable. On the other hand, a secondary battery can be charged with even less trouble than attends the trimming of an oil lamp. Hundreds of lamps can be charged at a time and at very small cost. An engine developing an effective five-horse power, and a dynamo-electric machine, correspondingly small, would suffice to charge 300 lamps at one operation. A discussion followed the reading of the paper, in the course of which the president, Mr. G. Baker Forster, and others spoke in favour of the lamp. Mr. Forster said he had no objection to the lamp as to its construction, and the weight might be got over.—Some of the speakers stated that one objection to Mr. Swan's lamp was that it could not be used in detecting the presence of foul air.—Mr. Swan explained that he hoped soon to add to his lamp an apparatus to detect foul air, and he had hopes of being able to reduce the weight of the lamp.—On the motion of the President, seconded by Mr. Baker Forster, a vote of thanks was passed to Mr. Swan, who, in returning thanks, said that he felt very much encouraged by the way the meeting had received the lamp, and he would prosecute his experiments further, in the hope that at some future time—and perhaps not a very distant time—he would be able to show them a still further development of the lamp.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 88.)

In the electromagnetic scheme we have the equations of a dynamical system, involving the potential energy of elastic displacement (or of electric polarisation, if that very vague term be preferred ; *any* vector function may be made up of polarised elements, whether it be solenoidal or polar, so it is as well not to attach too much importance to the idea of polarisation), the kinetic energy (or magnetic energy), probably of a rotational motion, and dissipation of energy by forces analogous to frictions proportional to velocities, when the electric current in a conductor is taken as a generalised velocity. There is nothing peculiarly electrical until we specify the connections of the different magnitudes. It is one out of the infinite number of dynamical systems subject to $Q+\dot{U}+\dot{T}=0$; the general equation of activity when no energy is communicated to the system, nor allowed to be withdrawn except through the irreversible frictional forces.

The three qualities to which c, μ, and k refer, relate to the potential energy, the kinetic energy, and the dissipativity. In order to render practically simple the theory of special cases, it is necessary to place restrictions upon their values, restrictions that we may know to be untrue. This is perfectly legitimate, as it is the common sense procedure in all matters of reasoning to simplify as far as possible. But it becomes necessary to be careful in the interpretation of the extreme results of a limited theory.

Consider, for example, the discharge of a condenser through a wire. The first approximation to its theory is got by ignoring inertia. If q_0 be its initial charge, that left at time t later is $q_0\epsilon^{-t/t_1}$, where t_1 is the time constant, the product of the capacity of the condenser and the resistance of the wire. An appropriate mechanical illustration is the restoration to equilibrium of a bent spring of negligible mass in a viscous fluid.

But if we push this to extremes, by shortening the discharge wire indefinitely, this theory says that the discharge will always be of the same character, though finally instantaneous. This is entirely wrong. The influence of inertia may be negligible when the resistance is great, but is not when it is small. We allow for inertia by introducing the coefficient of self-induction of the circuit, bringing in an electromotive force proportional to the rate of decrease of the current. Then we find that when the resistance of the wire is below a certain value, the discharge becomes oscillatory. This is quite correct, and the theory as amended is then true within a far wider range than before. But it, again, must not be pushed to extremes. It shows that if the resistance be reduced to nothing, whilst the coefficient of self-induction of the circuit is finite, as it must be, the oscillations continue for ever undiminished in strength, with frequency $(sp)^{-\frac{1}{2}}$, if s be the coefficient of self induction and p the capacity of the condenser. *I.e.*, short-circuiting a condenser would never get rid of its charge, except momentarily, when the energy is all kinetic. Here, of course, the objection is that we cannot indefinitely reduce the resistance in circuit, on account of the resistance of the metallic coatings, previously neglected, when the external resistance was great in comparison. Allowing for that, we still have oscillatory subsidence. But when we consider further that a short-circuited condenser can scarcely be treated as a *linear* circuit, and that we have ignored the dissipation of energy by the oscillatory phenomenon in the magnetic field producing vibratory electric currents in neighbouring conductors, we see that the complete theory of a short-circuited condenser may be only roughly represented by taking into account three constants, the capacity of the condenser, the self-induction coefficient, and the resistance coefficient. What is true enough within certain limits (or uncertain, because no definite line can be drawn between the true and the false) may be wholly untrue beyond them, owing to circumstances of the minutest previous significance becoming then of (relatively) paramount importance.

Retardation in a $\mu=0$, $c/k=$ constant, medium.—This is a very singular case, and of considerable interest. In general, we have

$$\text{div.}\left(4\pi k+c\frac{d}{dt}\right)\text{E}=0,$$

to express the continuity of the true electric current, E being the electric force, k the conductivity and c the specific capacity.

It will be convenient to put $c/4\pi=p$. The new quantity p is the capacity per unit volume considered as a condenser. We may avoid ambiguity by using the word "specific" in connection with c, in the absence of a better nomenclature.

In any normal system $\frac{d}{dt}=n$, a constant, so that the above becomes

$$\text{div.}(k+pn)\text{E}=0; \quad \ldots\ldots \quad (117)$$

or, since the displacement is $\text{D}=p\text{E}$,

$$\text{div.}(k/p+n)\text{D}=0. \quad \ldots\ldots \quad (118)$$

Now, if there be no inertia, or $\mu=0$, and no impressed forces, we shall also have

$$\text{curl.E}=0, \qquad \text{or curl.D}/p=0. \quad \ldots \quad (119)$$

In (117), $(k+pn)$ is a function of position, k and p being variable from place to place, whilst n is constant. Apply Sir W. Thomson's theorem of determinancy. If $(k+pn)$ be everywhere positive, the only solution of (117), subject to the first of (119), is $\text{E}=0$. Similarly, if $(k+pn)$ be everywhere negative, the only solution is $\text{E}=0$. In both cases the point of the demonstration is that $\Sigma(k+pn)\text{E}^2$ is necessarily positive if $(k+pn)$ be everywhere positive, and negative if it be everywhere negative. This quantity $\Sigma(k+pn)\text{E}^2$ is $Q+\dot{U}$, and is therefore zero. It follows that in any normal system $(k+pn)$ must be positive in some parts of space and negative in others (unless it be zero everywhere). Therefore, if k_1/p_1 be the least, and k_2/p_2 the greatest value of k/p, it follows that (k_1/p_1+n) is negative and (k_2/p_2+n) is positive. Hence the values of n for all the normal systems lie between $-k_1/p_1$ and $-k_2/p_2$. Or, their time-constants all lie between the greatest and least values of p/k. If then p/k is the same everywhere, there is only one rate of subsidence for any initial state, given by $(k/p+n)=0$. [To show that there cannot be imaginary n's, make use of $\text{U}_{12}=0$, $\text{Q}_{12}=0$, applying them to the solutions corresponding to a supposed pair of imaginaries. It follows that the unreal part of the roots is zero, and that the normal functions vanish in the case of equal roots.]

Given that the initial displacement is D_0 in a medium in which p/k is constant, and $\mu=0$, and that it is left without impressed force, we therefore obtain the subsequent state in the following manner. Let

$$\text{div.D}_0=\rho_0,$$

so that ρ_0 is the initial electrification. Find D_1, such that

$$\text{div.D}_1=\rho_0, \qquad \text{curl.D}_1/p=0.$$

D_1 is uniquely determinable by these conditions. Then $\text{D}_0=\text{D}_1+(\text{D}_0-\text{D}_1)$, where (D_0-D_1) is a system of closed displacement. It will subside instantaneously, leaving D_1, which will then subside so that the displacement D at time t later is given by

$$\text{D}=\text{D}_1\epsilon^{-kt/p}. \quad \ldots\ldots \quad (120)$$

The conduction current is $k\text{D}/p$, and the displacement current the negative of the same, so that the true current is zero. It is not a case of propagation at all, every elementary condenser discharging through its own resistance. It is the instantaneous vanishing of the closed displacement that is connected with progagation, it being what would happen if $k=0$ with the same distribution of p. First the displacement readjusts itself to make the electric force polar with the same electrification ; and then what is left subsides everywhere at the same rate, according to (120).

Now, any distribution of impressed force sets up a corresponding distribution of closed conduction current, and, therefore, since k and p are everywhere in the same ratio, of closed displacement, without electrification. But it is only displacement with electrification that has a finite rate of subsidence. Hence there is no retardation whatever in connection with impressed force. However it vary with the time, the corres-

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ponding displacement will vary with it instantaneously. Evidently this is a case in which inertia is not negligible. Maxwell, Vol. I., treats of the case p = constant, k = constant. The extension to p/k = constant allows us to distribute capacity as we please, and so obtain immediately the solutions of various problems connected with shunted condensers.

Now let there be inertia. Although (119) is no longer true, yet (118) is; and, since $(k/p+n)$ is constant, it may be written

$$(k/p+n)\text{div.D} = 0.$$

There is, therefore, no electrification in any normal system, unless $(k/p+n) = 0$. It follows that if there be electrification initially, the above process of dividing D_0 into D_1 and $D_0 - D_1$ is applicable to give us the part of the subsequent state depending on electrification. Thus (120) is true whether there be electro-magnetic induction or not, the left number, however, being not the complete displacement, but only that depending upon the initial electrification. The other part of the initial displacement, $D_0 - D_1$, will subside, not as before, instantaneously, but according to the nature of the normal distributions other than the $(k/p+n) = 0$ solution, depending upon the distribution of k and μ in space, and also upon the initial state of magnetic induction.

Why (120) is true in spite of inertia, is because there is no true current, the force being polar, and therefore no electromagnetic induction in connection with the electrification solution. As before, no electrification can be produced by any impressed forces, so that the $(k/p+n) = 0$ solution may be left out of account. The retardation in connection with the effects of impressed force will depend wholly upon the other n's.

As a simple application of the preceding, let $k = 0$ everywhere except in a single wire, forming a closed circuit. It is a perfectly insulated dielectric wire whose conductivity may vary as we please along it, provided its capacity vary in the same ratio. Let now k and p signify the conductance and capacity per unit length of wire, and D the total displacement across its section. Then D/p is the electric force per unit length, and

$$\frac{d}{dx}\left(k+p\frac{d}{dt}\right)\frac{D}{p} = 0$$

is the equation of continuity, if x be distance measured along the wire. Or

$$(k/p+n)\frac{dD}{dx} = 0,$$

in a normal system. If then D_0 be the initially given displacement, divide it into D_1 and $D_0 - D_1$, such that

$$\frac{dD_1}{dx} = \frac{dD_0}{dx} = \rho_0,$$

the initial electrification of a cross section, and such that the E.M.F. round the circuit is zero. At time t later, the displacement is

$$D = D_1\epsilon^{-kt/p}; \quad . \quad . \quad . \quad . \quad . \quad (121)$$

the part $D_0 - D_1$, which is closed, and is the mean initial displacement all round the circuit, instantly vanishing (if there be no inertia). As before, there is no true current during the subsequent subsidence. By the "mean" displacement is meant the quotient of the total initial E.M.F. round the circuit by the total inductive resistance, that is $(\Sigma D/p) \div (\Sigma 1/p)$, the summation extending round the circuit.

To corroborate, insert a conductor in the circuit having no capacity. There will now be two normal rates of subsidence, one of which is the previous. If n_1 be the new n, it is given by

$$0 = K + K_1 + Sn_1,$$

where K and K_1 are the conductances of the old and of the new wire, and S is the total capacity of the old wire, *i.e.*, $S = (\Sigma p^{-1})^{-1}$, the reciprocal of the sum of the "inductive resistance" round the circuit. The solution will now be

$$D = (D_0 - D_1)\,\epsilon^{n_1 t} + D_1\epsilon^{-kt/p} \quad . \quad . \quad . \quad (122)$$

As the auxiliary wire is shortened, n_1 goes out to negative infinity. Thus we return to the former instantaneous subsidence of the mean displacement when the whole wire has capacity, (122) becoming (121). When K_1 is finite, there is necessarily electrification somewhere; if not in the old wire itself, then at its ends, where it joins on to the new one. If the circuit be open instead of closed, there will be no instantaneous subsidence in any case; the solution is then (121) with D_0 instead of D_1 on the right side.

Any impressed force in the circuit will only suffer retardation in its effects as regards the n_1 term. It would be very convenient, as well as wonderful, if some ingenious inventor could construct a telegraph cable whose electrostatic capacity should be in the conductor instead of outside it. Having it there, however, a first approximation towards lessening the retardation is to give greater conductivity to the insulating covering. Even a leakage fault raises the speed of working considerably. Nothing is worse for rapid signalling (when pushed to limiting speeds), than the most perfect insulation. The lower it can be made (natural high conductivity, not due to faults which by getting too bad would stop communication) consistent with getting enough current at the receiving end, the better, and much better, it is for the signalling. Of course there are other considerations, but we must return to the immediate subject.

We can easily obtain the effect of inertia in modifying the solution (121). Let s be the coefficient of self-induction per unit length of wire, constant for purposes of calculation, and really so if the wire be circular. Let also k and p be constant. We have only to examine how $(D_0 - D_1)$ the closed displacement subsides, in which alone electro-magnetic induction is concerned. Let Γ be the true current over the cross-section, like D. The electric force to correspond is that of inertia, viz., $-s\dot{\Gamma}$. Hence

$$\Gamma = \left(k+p\frac{d}{dt}\right)(-s\dot{\Gamma}), \text{ or } \Gamma = (k+pn)(-sn\Gamma),$$

in a normal system; and the determinantal equation is

$$spn^2 + skn + 1 = 0,$$

giving the two n's

$$n_1 \text{ or } n_2 = -\frac{k}{2p} \pm \left(\frac{k^2}{4p^2} - \frac{1}{ks}\right)^{\frac{1}{2}}.$$

Besides the closed displacement, the initial current may be arbitrary. Let it be Γ_0. Then at time t later,

$$\left.\begin{aligned} \Gamma &= \frac{\Gamma_0 + n_1(D_0 - D_1)}{2+ksn_1}\epsilon^{n_1 t} + \frac{\Gamma_0 + n_2(D_0 - D_1)}{2+ksn_2}\epsilon^{n_2 t} \\ D &= -spn_1 \times \text{ditto} \qquad -spn_2 \times \text{ditto} \qquad + D_1\epsilon^{-kt/p} \end{aligned}\right\}$$

The current is oscillatory if

$$k/p < 2/(ks)^{\frac{1}{2}},$$

and non-oscillatory if it be greater. This differs completely from the condenser and coil theory; for now we get oscillations by reducing the self induction, whereas in the other case, it is by reducing the self induction that we get rid of oscillations.

Although in this solution we take into account the magnetic field, yet we only regard that part of the electric field that is within the conductor. So that the specific capacity c in the wire must be much greater than in the surrounding air to render the latter negligible.

Art is long, but space is short. The application to shunted condensers is therefore left over.

(To be continued.)

INFLUENCE OF THE MOON ON A MAGNETISED NEEDLE.—M. G. Ligner has made a remarkable communication to the Meteorological Society of Austria. He has ascertained after a number of careful experiments that the moon has an influence upon a magnetised needle varying with its phases and its declination. The phenomenon is said to be more prominently noticeable when our satellite is near the earth, and to be very marked when she is passing from the full to her first or second quarter. The disturbances are at their maximum when the moon is in the plane of the Equator, and are greater during the southern than the northern declination.

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THE STEAM ENGINE INDICATOR.—XII.*

BY AMICE.

The hyperbolic curve, which is the form of curve obtained by plotting ordinates of pressure and abscissæ of volume of a successively expanded gas, may be constructed by several graphic methods, one of which we will now take as being the simplest for indicator diagram work, as the lines drawn to divide the diagram into a number of equal parts readily form construction lines.

In the diagram (Fig. 40) let L L be a line representing the atmospheric pressure by its distance above the line V′ V, on a scale of 50lb. to the inch; the line V′ V will then represent the line of true vacuum or of no pressure, and will be 14·70lb. per square inch below L L. The line V′ V, as usual, also represents volume, and the vertical ordinates represent pressure. V′ V may also represent the stroke, or that part of the cylinder through which the piston moves. The length A D is that part of the stroke throughout which steam is admitted to the cylinder. Upon A D erect the verticals A B and D C, their height being such as to represent, say, 75lb., atmospheric pressure included. At a scale of 50lb. to the inch the height A B will then be 1·5in. The rectangle A B C D will then represent the volume and pressure of the steam during admission, or may represent one volume of a gas. We will assume that admission takes place during one-fourth of the stroke; the remainder of the stroke we divide into any number of parts which may be equal parts. In our diagram each part is taken as half A D. We will now suppose the volume is allowed to expand into a space equal to one volume and half, or to expand to line 1 1. Now, drawing the line A1, we cut the line C D at E, and by producing E E′ parallel to V′ V, we cut the line 1 1 at E′, and this is the second point in our hyperbolic expansion curve, C being the first point. Similarly, by drawing the lines A2 A3 A4 A5 A6, we cut the line C D at points F G H I J, and these points produced at F′ G′ H′ I′ J′ cut the lines 2 3 4 5 6 at points which are the succeeding points in our hyperbolic curve. It will be seen that when the original volume has been expanded into two volumes the pressure is halved; when expanded to three volumes the pressure is reduced to one-third, as will be found by measurement. The lines below the diagram show this at a glance. We adopted this method of constructing the hyperbolic curve in diagrams Figs. 36 and 38. By reference to these it will be seen that in Fig. 36, in which is an indicator diagram from a high pressure non-condensing engine, the pressure throughout the greater part of the stroke is maintained much above that assigned by the law of relation between volume and pressure, the hyperbolic curve being much below the actual curve, showing that a very large amount of steam is condensed in the early part of the stroke and re-evaporated during the latter part, or that the steam ports and clearance spaces were very large, so that a great volume of steam was necessary to fill these, this volume coming into play during the expansion part of the stroke and maintaining the pressure. In the diagram it will be seen that we had added about 4 per cent. for the volume of the steam filling these spaces, but it was probably very much more than this, 7 per cent. being a common quantity.

The properties of the hyperbolic curve enable us to assign a point in the stroke to which steam must be admitted to give the indicator curve of expansion, or rather a point to which steam would have to be admitted to give that curve if steam were not condensed in the early part of the stroke in unusual quantities. This point is given at K on the line B B′ of Figs. 36 and 38, and is found as follows:—A point in the indicator diagram is chosen at which the expansion curve has become steady, as at K on the line 4, 4, Fig. 36, or on the line N5 on Fig. 38. The line 4, 4 or N5 being extended to the absolute vacuum line, the line 4 B′, Fig. 36, or N N, Fig. 38, is drawn, and

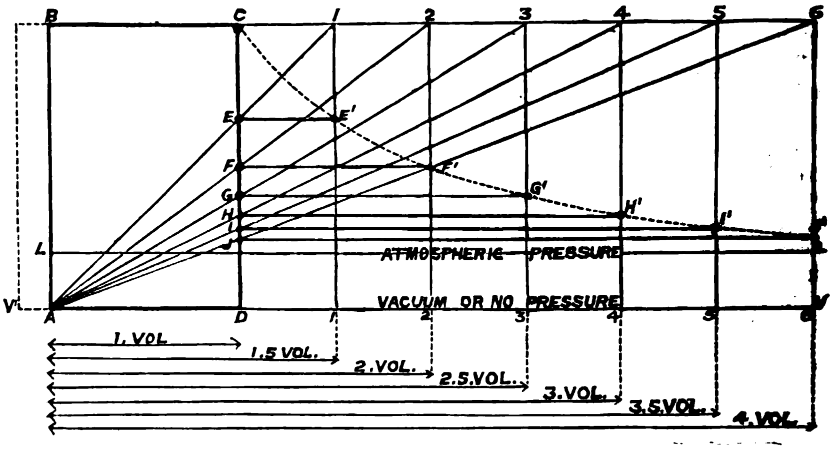

Fig. 40.

parallel thereto is drawn the line K K, starting from the point chosen in the indicator diagram curve. The point K on

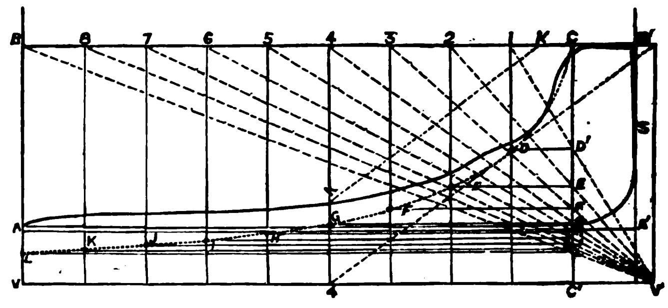

Fig. 36.

the admission line represents the point at which steam would have to be cut off to give the curve actually obtained, were it not

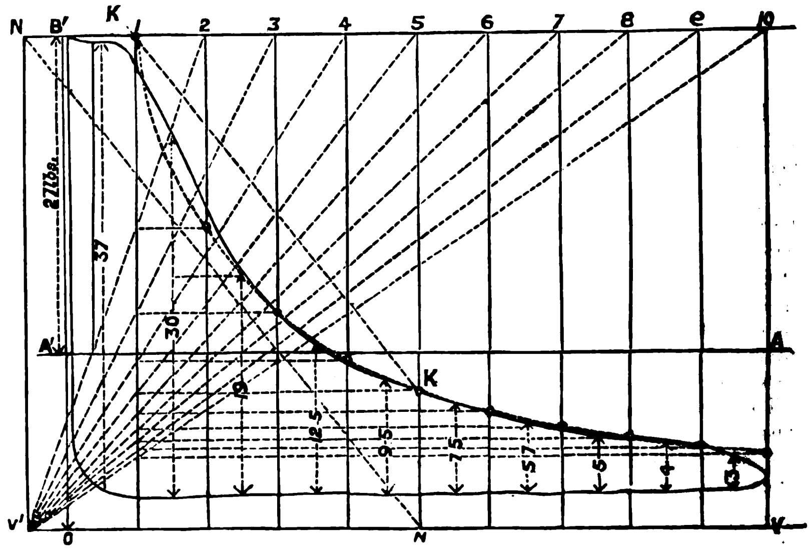

Fig. 38.

that initial condensation causes the admission of a quantity of steam which is afterwards re-evaporated at the lower pressures during expansion. The distance N, K represents, then, the volume of steam necessary to produce the curve the indicator has given.

Turning to Fig. 38, it will be seen that although the range of expansion was very large, the actual indicator diagram

* For Art. 11, see *The Electrician*, 4th December, 1885.

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curve follows very nearly the theoretical curve drawn by allowing about 7 per cent. for steam used in filling ports and clearance spaces. The actual curve is rather higher at the commencement, and only a little lower at the latter end of the stroke than theory demands. The engine from which the diagram Fig. 38 was taken was working with a good steam jacket, while Fig. 36 was taken from a cylinder without a jacket, and from an engine using much higher initial pressure.

In further illustration of Boyle's law, we may take the simple diagram given at Fig. 41. Here A D E C represents the original volume. Now, suppose the volume doubled and the pressure correspondingly reduced to one half. We then get the rectangle, whose height is D′ E′ instead of D E, and E and E′ form two points in a hyperbolic curve. By again doubling the volume, we get a rectangle whose height is D″ E″, and the corner E of the rectangle forms the third point in the curve. By again doubling the volume, so that it fills a space A D‴, we get a rectangle whose height is D‴ B‴, and the corner B‴ forms the fourth point in the curve. By again doubling the volume the fifth point E and the curve may be indefinitely extended

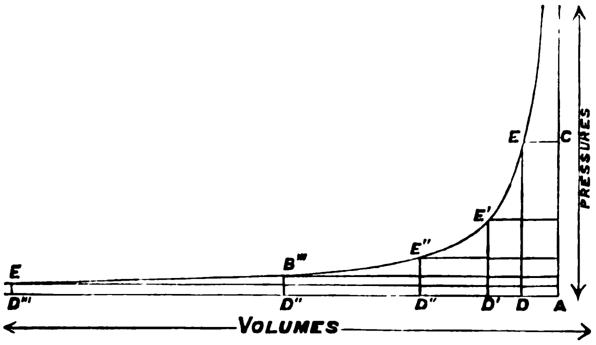

Fig. 41.

in this direction. On the other hand, if, instead of expanding from D E, we compress, say, double the pressure and half the volume, we get a point by which the curve may be indefinitely extended upward to represent compression instead of expansion.

A NEW APPARATUS FOR THE ESTIMATION OF COPPER.*

BY A. H. LOW.

The apparatus described was devised as the result of numerous experiments upon the electrolytic method of determining copper, with a view to obtaining a more rapid and certain method than that generally used. It consists essentially of a simple electrotyping apparatus, with a parchment-paper diaphragm, instead of the porous clay cylinder. The outer cell is a glass beaker, 1¾in. diameter, and 2½in. high, and the inner one a piece of thick glass tube of somewhat smaller diameter, open at the ends. The lower end is ground slightly conical, and the parchment paper diaphragm is stretched across it, and clamped tight by a conical silver ring fitting on the ground part. The upper end of the tube is stopped with a wooden plug bored through the centre to admit an amalgamated zinc rod which reaches nearly to the bottom, and there is also a groove in the side for the escape of gas. At the bottom of the beaker is placed a platinum electrode, consisting of a circular base plate as large as the beaker will admit, to which are united, by means of gold solder, several concentric cylindrical walls, about ½in. high. A strip of platinum, and a wire of the same metal attached to the outer wall, form the connection with the opposite electrode by means of a binding screw. The weight of the platinum electrode is about ¼oz. troy, and its surface on both sides is about twenty square inches. The tube is surrounded by a spring ring of sheet iron, with two horizontal arms attached, which support it on the top of the beaker, the level of the bottom being adjusted by sliding the tube in the ring.

The solution from which the copper is to be deposited must be always of about the same nature; slightly acid, with sulphuric acid, and contain about forty-five grains of chlorate of potash. The volume should be sufficient to fill the beaker to a depth of ¾in. When much iron is present in the substance under examination it should be previously removed, as it increases the electrical resistance. When the solution is prepared a mixture of sulphuric acid and water, in the proportion of 1 to 4, is poured into the inner tube to the depth of about 1in., the zinc rod is inserted and connected with the platinum electrode, and the tube is lowered until the diaphragm just touches the surface of the copper solution. The deposition of the metal begins at once, and is finished in from one to two hours, according to the amount of copper present. The weight of the sample operated on is in all cases 1 gram. If towards the end of the operation the solution becomes too warm, the beaker must be cooled by placing it in water to prevent the acid liquor attacking the deposited copper and re-dissolving it. The operation is completed when bubbles of gas are given off from the platinum electrode, and a drop of the solution no longer discolours sulphuretted hydrogen water. The tube and platinum electrode are then lifted together without disconnecting them, and the latter is immersed in a beaker of water, while the former is returned to its place. The electrical connection is then broken, and the electrode, after being washed first with water and then with alcohol, is dried and weighed. For further use the deposited copper is dissolved off the platinum by nitric acid. Before setting aside the tube it is well rinsed with water to remove the acid from the diaphragm, which will last for several operations. Examples of the application of the method to different copper ore and furnace products are given, and the results are practically identical with those obtained by electrifying with a battery current. The time occupied in the operation was one hour and a half in each case.

* *Proceedings* of the Colorado Scientific Society. Abstracted in *Proceedings* of Institute of Civil Engineers.

LITERATURE.

Lightning Conductors; their History, Nature, and Mode of Application. By Richard Anderson, F.C.S. Third Edition. [London: E. and F. N. Spon, 1885.]

In noticing the previous editions of this book it was stated that for historic information, for grasp of the whole subject, theoretically and practically, the work had no equal. All the praise that has been given to it is none too great, nor, indeed, would it be possible to estimate too highly the value of the book. The present edition "has been carefully revised," many chapters "have been rearranged and rewritten, and a considerable amount of new matter has been added." There is no doubt the author can justly claim that his work has "exercised a salutary influence in drawing public attention to the importance of the subject." The majority of accidents, so far as buildings at any rate are concerned, are, we feel sure, preventible; but, after all, it is comparatively few who trouble to obtain this protection. We believe that the periodic testing of lightning conductors is becoming more general, and this is important, for time in many ways degenerates the efficiency of the rod, so that what might when erected have been protective becomes a false and untrustworthy reed. Mr. Anderson has consistently advocated periodic testing, and has devised simple apparatus for the purpose, which is described in this work. Altogether the work is far in advance of any other publication on lightning conductors.

Electrical Saponification.—Prof. Rotondi has recently completed his experiments upon the application of electricity to the decomposition of concentrated salt solution into caustic soda and chlorine gas for commercial purposes. He has found that with a dynamo and diaphragms the process of saponification is easily effected by means of common salt and fat. The separation of the resultant products, glycerine, soap, and chlorine gas is a matter of no difficulty. No caustic soda is necessary for saponification.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in The Electrician, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

NOTICE.

"THE ELECTRICIAN" will next week be published on THURSDAY instead of on Friday, and all Contributions and Advertisements must reach the office not later than first post on WEDNESDAY.

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SCIENCE AND POLITICS.

How hard it is to maintain an attitude of impartial indifference during periods of great national excitement has just been illustrated in two very dissimilar quarters. The Church has been provoked out of its cautious neutrality by an attack upon its privileges; and, for reasons not perhaps so intelligible, the hierarchs of science—or, at all events, some of the most prominent of their number—have proclaimed their distrust of one political party, and openly taken sides with the other. The *rôle* of a bystander is generally an ignoble one, and when he is a looker on perforce, a sort of captive over whose booty a couple of ruffians are quarrelling, the temptation to take sides with one or the other becomes irresistible. This, however, is not exactly the position of the scientist. The multitude, it is true, are not enamoured of science, and are sometimes hostile to its achievements; but they are almost powerless as obstructives, and, at least for the present, science is as free and as hopeful under one English ministry as under another. But scientists are human beings; and as one of them declared the other day that if he had had a vote he would have given it against the party he had always previously voted for, we may conclude that his more fortunate *confrères* who possessed votes disposed of them under similar human promptings They will regret this none the more for the peevish threat to disfranchise the learned communities because they have dared to vote like educated citizens and not as party men.

But another and quite novel reason has been put forward to induce or to justify the severance of the scientific spirit from its traditional leading. A letter, to which special prominence was given in the columns of *The Times* during the thick of the General Election, drew attention to the ethical aspects of the strife in such a startlingly original fashion that the newspapers have hardly yet left off talking about it. The writer claimed to be a representative of science; the pursuit of science is the pursuit of absolute truth; the spread of science is rapidly supplying the world with a higher standard of truth than has heretofore prevailed, and a more sensitive conscience as regards the baseness of lying and the grandeur of unflinching veracity. How disappointing, then, how disgusting, it was to witness our foremost politician employing the subtleties of his intellect to explain away obvious facts, and spread glosses over palatable lies! Such was the drift of this remarkable letter, the moral of which points plainly to the scientific excommunication of political sophists in general and to that of their super-subtle chief in particular. Science turns its back upon all such, carrying the "standard of truth" along with it.

More power to its arm, say we; but we are not quite persuaded of the unbiassed sincerity of the standard bearer, who, we suspect, would have been less severe on the sophistry if the conclusion had pleased him better. Nor are we so confident about the attractiveness of the standard itself; for, bitter as is the reflection, it is none the less a fact that the very qualities which the champion of science, of pure truth, condemns most, are what the multitude relish best. If science can counteract this bad taste by inculcating a devotion to truth in politics, such as is essential in the examination of natural phenomena, it will indeed accomplish a kind of moral revolution. A scientific habit of thought brought to bear upon political questions is greatly to be desired; but side by side with the progress of science, and its application to public affairs, the tendency latterly has been to cast it aside, to relegate it to the planet Jupiter, as an obstructive factor in the path of social advancement. And the explanation is not far to seek. The object, the sole object, of scientific research is to ascertain facts, to get to the bottom of everything where truth is to be found. This is the scientist's goal, on the road to which he meets with no conflicting interests or temptations, and at the end of which his reward is sure. If *The Times'* correspondent had been more of a scientist and less of a politician for the moment, he would have remembered that the very reverse of all this is true of a political career. We need not particularise. The facts are too conspicuous. Selfish interests dog the footsteps of the politician whichever way he turns, and even his noblest aspirations cannot be severed from his personal ambition to realise them. As to political truths, well, such as are useful for his ends are brought into prominence, whilst those that are inconvenient or inopportune are discreetly ignored. This economy in the matter of "truth" has even been justified by the example of the scientific teacher who refrains from overloading the minds of his humbler pupils, or who propounds a working theory, for convenience sake, which he knows to be scientifically unsound. The pupils of the political platform are very humble indeed. If our great men of science object to the superficiality and falsity of teaching which is the inevitable consequence of politics made popular, they had better say so plainly; only it is rather late in the day. Meanwhile, we repeat, the multitude prefer things made easy and pleasant.

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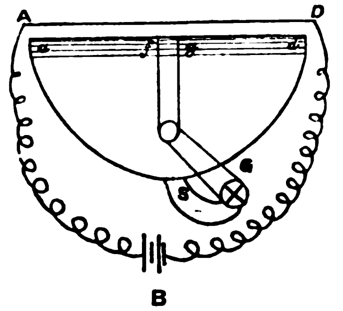
That the sophistry and apparent unscrupulousness complained of are due mainly to the character of the audience can be shown in a few words. First, it is a significant fact that, although the reproach is levelled at the head of one man, the defence has been taken up by his foes as well as by his friends. They all alike feel the partial truth of the accusation, and, without resenting it strongly, plead the exigencies of modern political life in extenuation. Secondly, it is notorious that he who is now described as the greatest culprit was himself but a few years ago a chief apostle of the verities; and it is well known that his enemies were dethroned because of their alleged unveracity. From these and other indications, therefore, we may infer that truthfulness is highly respected, if not always practised, in quarters the most suspected; and what the scientist has got to do is, not to raise the standard of truth, but to show how it can be followed with a tagrag and bobtail of ignorant self-seekers at your heels; or, better still, to teach us how the science of politics can be practised in these days without the help of this base following. Notwithstanding their many defects, common to all multitudes, there are reasons for asserting that the English populace resent a falsehood more fiercely than any other race of people. But it has to be found out; and however high their ideal of truth may become under the moral influence of either science or religion, the detection of falsehood is for men who can write letters to *The Times*, not for the average audience of a political spouter. Without knowledge and judgment a scientific love of truth will count for nothing; and seeing that we have deliberately taken the ill-informed and foolish into the national council, we have little right to be surprised that the art of political bamboozlery is attracting an increasing number of professors.

CORRESPONDENCE.

EXPERIMENT IN ELECTRIC INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Upon reading Mr. E. A. Williams's statements concerning electric induction in *The Electrician* for October 23rd, the following experiment suggested itself to me, which I think proves the correctness of our received theory in a very simple way. It gives an easy way to investigate the direction of the current in the part of the secondary circuit which is immediately under the inductive action of the primary current. The experiment may be familiar to others, but I have not seen it, and Mr. Williams says, in *The Electrician* for November 6th, that he is not aware of any investigation on this part of the circuit. I submit the experiment, and ask criticisms if it is not conclusive.



Let B A D be a primary circuit, with battery at B, and with arrangements to start, stop, and reverse the current at pleasure. Let *s a f o g d s* be the secondary circuit, with the part *a f g d* under the inductive action of the primary circuit A D. At *f g* is a short interruption, from which wires are brought down to *o*. A galvanometer, G, is arranged so as to be connected either with the wires at *o* or *s*. If with *o*, then the wires at *s* are joined together and the circuit is complete. If with *s* then the wires at *o* can be joined, and the circuit will be complete. Before closing the secondary circuit I closed the primary, and found that, despite all my precautions, the galvanometer needle was slightly affected by the currents, for I was alone, and had to bring the terminals near the galvanometer. The result was that the needle would swing *slowly* through about 4 scale divisions when the current was made, or broken, or reversed.

I now connected *s* with the galvanometer, and made the connections in such a way that by theory the effect of the secondary current would cause a deflection of the needle opposite to that of the primary current. When the primary circuit was closed the needle gave a sudden jump in direction indicated by theory, and then slowly swung back under influence of primary current. I opened the primary circuit, reversed it, &c., and all was in accord with theory. I now broke the circuit at *o*, leaving wires at *s* united with G, and now got no effect upon the galvanometer, showing that no current, or one too small to be detected, flowed from *a* to *d*, through *s*. I next joined the parts at *o* to G, so that the theoretical swing should be opposite to the swing caused by the primary, as above, and joined the parts at *s* directly.

I now closed the primary, and got a sudden jump of the needle in accord with theory, and next the slow swing due to the action of the primary current. Breaking the primary circuit, or reversing it, gave results in exact accord with our received theory. Opening the secondary circuit at *s*, I could get no effect upon the galvanometer. To sum it up, my experiment shows in a very clear manner, I think, that our received theory is correct. If Mr. Williams's theory about difference of electric potential between *a* and *d* were correct, there should be a greater current when the circuit is broken at *s* than when closed, for the whole flow of electricity due to this difference of potential should take place along *a d*, but I have shown that there is no flow, or else so small a flow as not to be indicated by my galvanometer.

On the whole I am inclined to think that our present theory is correct, and that his "cogent arguments" are not supported by facts.—Yours, &c., T. A. SMITH, Professor.

Beloit, Wis., U.S.A.

GAS PRESSURE ALARMS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the issue of *The Electrician* for October 9th last I find Mr. Tindall, of the Midland Association of Gas Managers, showed in action one of Bishop's electrical gas pressure alarms. I wish to say W. Valon, C.E., designed a similar apparatus for the gas works at Ramsgate about two years ago, and the work was carried out by me.

By inserting the above you will greatly oblige,—Yours, &c.,

W. COVINGTON,

Electrical Engineer to the Ramsgate Local Board.

8, Borough, Canterbury, Dec. 15, 1885.

SUBMARINE CABLES: EARTH CURRENTS.

BY A. E. BAINES.

When a submarine cable is tested with a view to the determination of its absolute insulation, or conduction resistance, or its electrostatic capacity, there are certain subsidiary phenomena to be considered and taken into account in order that correct results may be arrived at. Amongst the more important of these phenomena are the extraneous or *earth* currents which traverse the cable, both when one of its extremities is insulated or when both are connected, directly or indirectly, with the earth. When the cable is insulated at the far end of the line, and a test is being taken, at the near end, of the resistance which its gutta percha or india rubber covering offers to the passage of the current to the water which surrounds it, we require to observe the galvanometric deflections given through that

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covering by our battery. If those deflections do not correctly represent the value of a known electromotive force (E) through an unknown resistance (x) we can have no accurate basis for calculation. That is to say, if E is variable, and we have not obtained the amount of its variation, we cannot determine x, for we do not know E. Now our battery, we will suppose, has an E.M.F. (E) which is constant, and the earth, for the time being, has another E.M.F. (E_1) which is not constant, and which may or may not be of the same sign (+ or −) as the battery current we are employing. It therefore becomes necessary to observe the sign, and to calculate the value of E_1 in order that we may acquaint ourselves with the degree of error it introduces into the test. As regards the origin of these extraneous currents very little is known. Every electrician has a theory of his own. In all probability they are due not to one, but to a multiplicity of causes. It will be better for us only to consider effects.

If two insulated wires whose ends are to earth be laid or erected parallel, and in closer proximity of distance to each than to any other conductor, and a current of electricity be sent from the battery E (Fig. 1) along either circuit, in the

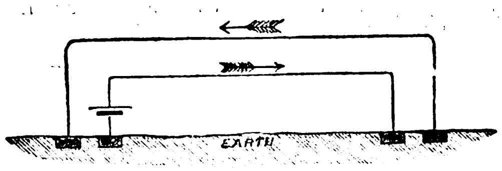

Fig. 1

direction indicated by the arrow, a second, sympathetic, current will, at the moment the circuit is closed, traverse the other line, but in the opposite direction. That is to say, if a copper or + *positive* current be sent along one line it will have the effect of *creating* a *negative* current in the other line, or *vice versâ*. This phenomenon is called *induction*, and the second responsive or sympathetic current is said to be *induced* by the action of the first.

The laws and principles of induced currents briefly stated are as follow:—The first impulse of the current in any conductor is to induce an *inverse* current in any other similar conductor which may be close to it; at the moment it ceases it produces a *direct* current. A current which *diminishes* in strength has also the latter effect, but one which *increases* in strength creates an *inverse* induced current. A *constant* and *continuous current, however, has no observable inductive properties.* From the above it will be seen that the induced current in any line depends upon the variation of another current for its creation. The current or currents flowing through the earth cannot be constant, but must, at equal or unequal periods, alter in strength, inducing in any neighbouring circuit *inverse* currents at each *increase*, and *direct* currents at each *decrease* of force. The E.M.F. of these extra currents is proportional to the E.M.F. of the primary currents.

Let us now take the case of a submarine cable, C, extending between two stations, A and B, a distance of, say, 1,000 knots. (Fig. 2.)

To all intents and purposes the earth is an electrical conductor through which currents of variable E.M.F. quantity and sign are always flowing. Moreover, it is an electrical conductor parallel to the cable circuit, which latter, although insulated at B, has a leak (due to the fact that nothing is an *absolute non-conductor*) through every inch of its gutta percha covering, or, in other words, from A to B. A variable current or currents of electricity proper to the earth, generated in the earth, no matter by what agency, and traversing the earth from A to B, will *induce* a current or succession of currents in the cable from B to A, or the reverse. The cable current in this case is therefore induced, will vary in strength or E.M F. and sign with the earth current proper, and as may be conceived will either militate against or increase the apparent strength of any battery current we may require to put into the cable. The deflections given by the battery (E) will, in point of fact, calling the induced current E_1, be $E+E_1$ or $E-E_1$. In both instances we require to eliminate the value of E_1 from our test, and this can be done in the manner shown in Fig. 2.

A little experience will enable the operator to detect and eliminate the values of the earth induced currents in divisions of the scale from the deflections $d \times \left(\frac{G+s}{s}\right)$—where d is the cable reading in divisions, G the resistance of the galvanometer in ohms, and s that of the shunt in ohms—obtained with the cable and battery. For instance, if E_1 were found to vary between 50 and 100 + while it was wished to use a − battery current (or zinc to line) for testing, it would be sufficient for all practical purposes to subtract a mean of $75 \times \frac{G+s}{s}$ from the *full* cable readings. Subtraction in this case because a + current coming from the line is equivalent to a − one passing into it. If the signs are the *same* the extra deflection due to E_1 must be *added*.

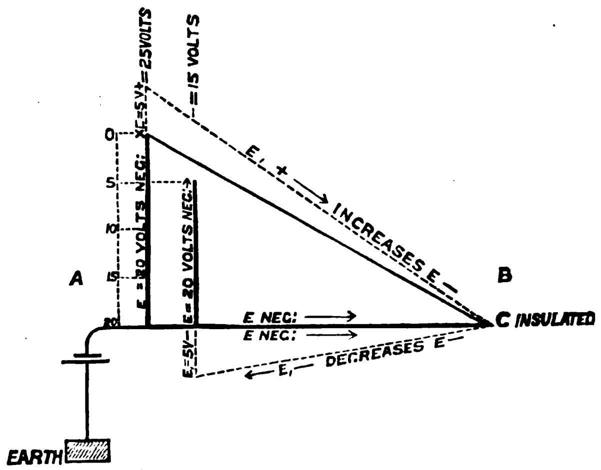

Fig. 2.

In the above example the mean of E_1 (5 volts) is supposed to be constant; E is negative. The thick vertical line to the left represents the *true* strength of E, and plus the dotted line above it shows the *apparent* strength, or $E+E_1$; that is if E_1 be of positive sign. The thick vertical line to the right shows the apparent diminution of E due to E_1 being also negative (or of the same sign as E), as shown by the dotted line below it. In the first case the result is an apparent decrease of R, while in the second R appears to be higher than it really is, for the reason that deflection and resistance are in the inverse ratio.

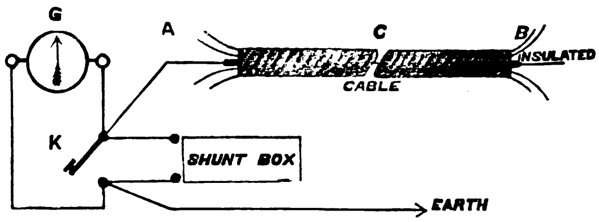

Fig. 3.

Practical connections at Station A preliminary to insulation test. Use same shunt as that during electrification of cable, if possible, to simplify calculation; if not, use any convenient shunt. With K open take readings of induced current flowing from cable until its strength and nature are understood.

Let d = deflection with cable and battery, E, (negative current) = 250 divs.

„ d_1 = mean deflection with cable and earth current E_1 (positive current) = 75 divs.

„ G = 6000 ohms (galvanometer resistance).

„ s = 1000 ohms (shunt resistance).

Then $d \times \left(\frac{G+s}{s}\right) - d_1 \times \left(\frac{G+s}{s}\right)$ = true deflection with cable and battery.

Substituting values we get $\frac{6000+1000}{1000} = \frac{G+s}{s} = 7$, and $250 \times 7 = 1750$ = observed d.

$d_1 \times \frac{G+s}{s} = 75 \times 7 = 525.$

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Then $1750 - 525 = 1225$ = true d or true deflection given by known E.M.F through x.

It is better to eliminate the exact number of divisions due to E_1 at each 15 seconds or minute of electrification of the cable instead of taking an approximate mean, but such a course requires experience. Indeed, in practice, E_1 is but seldom considered in insulation tests, the mean of five minutes each of zinc and copper readings being taken as correct. This is objectionable, in that it supposes the sign of E_1 to remain constant for ten minutes, a thing that very seldom happens. It is safer to observe E_1 before applying zinc to line, and again after Z has been discharged to earth, and before copper to line is applied. In this way you get a more exact knowledge of the variability of E_1.

We will now proceed to observe what takes place when *both* extremities of the cable are put to earth; direct in one case, and through a galvanometer in the other. Here a somewhat different phenomenon is noticeable. An earth current flows in the cable, but it is no longer a simple earth-induced current; it is probably due to a difference of electrical potential or pressure at the points A and B, and may traverse the line from either of those points to the other. A variety of causes may also contribute to the origin of this extra current. In copper resistance tests it gives infinite trouble to the electrician, who has to follow it in all its variations, and make allowance for its effect. Its value is easily calculated.

Let R = resistance of copper conductor of cable.
„ r = „ „ shunt used while observing E_1.
„ R_1 = high resistance coils in circuit for constant of galvanometer.
„ D = deflection for constant of galvanometer.
„ d_1 = „ given by E_1.
„ E = E.M.F. of testing battery in volts.
„ M = multiplying power of constant shunt $= \frac{G+s}{s}$ (1).
„ m = „ „ „ shunt used for $E_1 = \frac{G+s}{s}$ (2).

Then if E_1 is smaller than E,

$$E_1 = \frac{(R+r)\,m\,d_1\,E}{R_1 M D} \quad . \quad . \quad . \quad . \quad . \quad . \text{ volts.}$$

Example. With a battery of 20 volts, a galvanometer of 6,000ω resistance, and a shunt of 50ω resistance we have obtained a deflection, D, through 100,000ω (R_1) of 500 divisions.

$$M \therefore = \frac{6000+50}{50} = 121,$$

and $500 \times 121 \times 100{,}000 = 6{,}050{,}000{,}000 = R_1\,M\,D$.

Substituting the cable (R) for R_1, the shunt remaining unaltered, we get a deflection d_1 of 75 divisions through a cable resistance of 10,000ω (R) and shunt 50ω (r); m is also = 121 in this case.

$\therefore 75 \times 121 \times 10000 + 50 \times 20$ volts $= 1{,}824{,}075{,}000 = (R+r)\,m\,d_1\,E$

and $\frac{1{,}824{,}075{,}000}{6{,}050{,}000{,}000} = {\cdot}3015$ volt $= E_1$.

For this example I have taken what may be thought in such a long cable an exceptionally low value for E_1. I have found the simple earth current to vary between a fraction of a volt and 5 volts, seldom more. The induced E_1, however, in cables laid N. and S. not unfrequently exceeds 15 or 20 volts.

MINIMUM E.M.F. IN TRANSMITTING POWER.

Our New York namesake gives the following article by Prof. H. S. Carhart:—

The prominence attained by recent practical experiments in the electrical transport of power justifies the fullest theoretical discussion. Any light that theory can throw upon the subject must be of some value. I shall therefore attempt to make clear the question of minimum E.M.F. that can be employed under the defined conditions, even at the risk of being too mathematical for some readers.

So far as observed the discussions of the general problem have proceeded upon the following basis:—Given the E.M.F. of the generator and the resistance in circuit, to find the *maximum* rate of working or the maximum work that the motor can do. What I propose is, given the resistance in circuit and the work required of the motor, to find the *minimum* E.M.F. This latter is the form in which the matter presents itself as a practical problem. I shall first give the usual solutions corresponding to the former conditions, and then the new solutions with the latter defined ones. In each case R and C denote resistance and current strength, E and E_1 the direct and counter E.M.F. of generator and motor respectively, and W the work done by the motor per second.

1. Given E and R to find C and *maximum* W.

a. Algebraic solution. The total energy of the current is divided into two parts, one of which goes to heat the conductor, and the other is absorbed by the motor and converted into useful work. Hence

$$C E = C^2 R + W \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The solution of this equation of the second degree is

$$C = \frac{E \times \sqrt{E^2 - 4RW}}{2R}$$

Plainly $4RW$ cannot exceed E^2, or C would have an "imaginary" value, which is impossible. W will therefore be a maximum when $4RW = E^2$. Hence,

$$W = \frac{E^2}{4R} \text{ and } C = \frac{1}{2}\frac{E}{R}$$

The current for maximum work is therefore reduced to half the value it would have with the motor at rest, and $E_1 = \frac{1}{2}E$. This is known as Jacobi's law. It is not the law of efficiency but of maximum activity.

In the above values W and C are expressed in given terms; and we have the further deduction that for maximum rate of working the counter E.M.F. of the motor equals half the direct E.M.F. of the generator.

b. Solution by the calculus. By transposition of . . (1)

$$W = C E - C^2 R \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Whence $\frac{dW}{dC} = E - 2CR = 0$ for the *maximum* value of W, since the second differential is negative. Therefore

$$E = 2CR \text{ and } C = \frac{1}{2}\frac{E}{R} \text{ as before.}$$

The value of W may be found by substituting the value of C in (2).

2. Given W and R to find C and *minimum* E.

a. Algebraic solution. The work done by the motor is

$$C E_1 = \frac{E_1(E - E_1)}{R} = W \quad . \quad . \quad . \quad . \quad . \quad (3)$$

If W and R are constants, then is $E_1(E - E_1)$ a constant also. Now, when the product of two terms is a constant their sum is a minimum when they are equal to each other. But the sum of E_1 and $E - E_1$ is E, the E.M.F. of the generator. Hence E is a minimum when E_1 equals $E - E_1$; or $E_1 = \frac{1}{2}E$. This condition corresponds to Jacobi's law, as might have been inferred directly, because the conditions determining maximum rate of working with a given E.M.F must also define the minimum E.M.F. required to do a given amount of work.

To determine E and C in terms of W and R, substitute for E_1 in (3) its value $\frac{1}{2}$ E, and we have

$$E^2 = 4RW, \text{ or } E = 2\sqrt{RW}.$$

Whence $$C = \frac{1}{2}\frac{E}{R} = \sqrt{\frac{RW}{R^2}} = \sqrt{\frac{W}{R}}$$

b. Solution by the calculus. From equation (1)

$$E = CR + \frac{W}{C} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

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Whence $\frac{dE}{dC} = R - \frac{W}{C^2} = 0$ for *minimum* value of E, since in this case the second differential coefficient is positive. Hence,

$$R = \frac{W}{C^2} \text{ and } C = \sqrt{\frac{W}{R}} \text{ as before.}$$

Substituting the value of C in (4) and

$$E = 2\sqrt{RW}$$

Also $$CE_1 = W \therefore E_1 = \frac{W}{C} = \sqrt{RW}$$

Therefore $E_1 = \frac{1}{2}E$ as above.

It appears, therefore, that the E.M.F. varies as the square root of the resistance. Hence, if any reduction of E.M.F. is attempted by reducing the resistance, the reduction of the latter must be much more rapid than the former. If R is reduced to one-fourth, the E.M F. is reduced only to one-half. But the resistance may be increased fourfold by merely doubling the E M.F., the same amount of work being done with the same efficiency. Whenever attempts are made to work with low E.M.F. as considerations of safety demand, then difficulties at once present themselves. The above discussion shows that with the requirement of a given amount of work to be done by the motor, the E.M.F. has a minimum value which cannot be reduced except by an inordinate and impracticable reduction of resistance.

To apply the results to a concrete example. Assume twenty locomotives on a New York elevated road to represent 2,200 horse-power. If the electric motors replacing them have an intrinsic efficiency of 90 per cent. in round numbers 1,800,000 watts of energy must be supplied to the motors per second. If the resistance in circuit is 0·072 ohm, then

$$E = 2\sqrt{RW} = 2\sqrt{1,800,000 \times 0\cdot072} = 720$$

and

$$C = \sqrt{\frac{W}{R}} = 5,000$$

With an assumed resistance of about three-quarters of an ohm the minimum E.M.F. required to transmit to the motors 2,200 horse-power is 720 volts, and the current is 5,000 amperes.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The annual meeting of this Society was held at the Institute of Civil Engineers, on Thursday evening, 10th inst., when, previous to the usual business, the report for the past year was read, and the officers for the ensuing year were elected. The report, after referring to the losses the Society had sustained in the deaths of Mr. Davey, Prof. Fleeming Jenkin, and others, announced that the Society's premium had this year been awarded to Prof. O. Lodge for his paper on the "Seat of the Electromotive Force in the Daniell Cell;" the Paris premium was given to Mr. W. H. Snell for his paper on the "Distribution of Electricity," whilst to Captain Sankey for his contribution on "Electrotyping with a Dynamo" had been assigned the Fahie prize. Steps had been taken by the Society to forward the object of a uniform and simplified electrical nomenclature advocated by Prof. Jamieson in the early part of the year, and the co-operation not only of the chief professors at English Universities, but of M. Hospitalier, and other leading electricians in Paris, had already been secured. A sub-committee was formed and now had the matter in hand. Mention was made of the formal Resolution of the Society forwarded to the Board of Trade with reference to the objectionable and impolitic clauses of the Electric Lighting Act; and hopes were entertained that some legislative action might shortly be taken so that the law would no longer obstruct, but rather help forward, the work of Electric Lighting. Dr. Fleming's suggestion recently laid before the Society for the creation of an electrical standardising institution was now receiving the careful consideration of the Council. The visit of the members to Swindon at the invitation of the president, Mr. Spagnoletti, was referred to in appropriate terms, after which the highly satisfactory financial condition of the Society was briefly set forth; and after a reference to the alteration made in this year's ballotting forms whereby twice the number of names required were submitted for selection, the report concluded with the Librarian's statement of the progress made by the Society's reading room and library during the past year.

A vote of thanks to the Council of the Institute of C.E. for the continued loan of their Lecture Hall was then proposed by Prof. Perry and carried unanimously. Votes of thanks were also accorded to the Foreign Secretaries of the Society, to the Hon. Treasurer, Mr. E. Graves, to the Auditors, and to the Hon. Solicitor, Mr. Bristow.

While the scrutineers were examining the balloting papers, a task which on this occasion occupied fully an hour and a half, Mr. WALTER J. MURPHY, assistant electrician of the telegraph ss. "Great Northern," read a paper describing, or rather suggesting, a method of eliminating the effects of earth and polarisation currents in fault testing; after which the Secretary read a paper by Mr. H. KINGSFORD, Associate, also relating to cable testing. The latter paper we print at length below. Mr. Murphy drew attention to the several defects of Mance's method, chiefly due to the variation of the testing current, and described an instrument designed by himself to obviate these defects. Mr. Murphy's suggestion, however, was not favourably received by the experts present, who, forming their judgment upon the diagrammatic testing method exhibited by the author, were of opinion that it would not do what was claimed for it. Mr. KINGSFORD's paper is as follows:—

A Method of Localising a Fault in a Cable by Tests from One End Only.

In experimenting some years ago to discover a trustworthy method of localising a partial fault in the case of a laid cable where no return wire was available, unsatisfactory results were nearly always obtained from the application of "Blavier's" tests pure and simple. I was then led to investigate for the first time a formula which until then had never interested me; total severances of the cable, or faults when both ends were available, having so far been the only defects which had occupied my attention. It needed, of course, but little consideration to trace the source of error, as testing to breaks had assured me of the well-known fact that the resistance of an end varies (as a rule considerably) in some ratio to the current through it, decreasing, with increased electromotive force, until a minimum resistance has been obtained. A partial earth would, of course, be effected in the same way by the so-called "polarisation." To obviate the error due to this fact I devised a method which I shall presently state, and an account of which I have long intended to publish. It is most probable that I should have delayed longer, being anxious to publish at the same time other matter which I have not yet had time to work into shape; but I was reminded of my intention by reading a very interesting article by Messrs. J. Anderson and A. E. Kennelly, in *The Electrician* of July 17th, 1885. These gentlemen recognise the source of error which I mention as accompanying the simple "Blavier," and suggest for its elimination a test the main principle of which is the same as that which characterises my own modification of that method. For reasons, however, which will, I think, be considered by most electricians as sufficient, I can but think that my method may in some cases be preferable. That of Messrs. Anderson and Kennelly requires an observer, battery, and a set of instruments at each end of the cable—a mode of testing which would be apt at times, I consider, to involve some little anxiety at least on the part of the responsible person. My method requires tests from one end only, and is as follows:—

In order that the current through the fault may be the same when the distant end is free as when it is to earth, proceed thus: First, take ordinary "Blavier," approximate distance of fault, and let that approximation from testing station $= x$ in ohms; from that we obtain approximate resistance from the fault to the distant end $- y$ ohms $-$, and approximate resistance of fault $- z$ ohms $-$. With these data we go to work to obtain an approximation to the resistance which must be inserted at the home end of the line when testing cable free at distant end. Should the test be taken on shore, there is perhaps no better method to adopt than that known as reproduced deflection. Using this method,

Let r = resistance of battery;

,, r' = resistance of well-shunted galvanometer, or $\frac{gs}{g+s}$

,, a = E.M.F. of battery.

Then $\frac{a}{r+r'+x+z} = \frac{a}{f}$ = current through fault when line is free at distant end;

and $\frac{a}{r+r'+x+\frac{yz}{y+z}} = \frac{a}{g}$ = current through x when line is to earth at distant end.

Portion of $\frac{a}{g}$ flowing through fau't = roughly $\frac{\frac{a\,y}{g}}{y=z}$

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Let this quantity $= \frac{a}{h}$, then $h - f$ will represent the first approximation for resistance to insert, in ohms, or R_1.

Then, placing R_1 in circuit, we now take another observation with the line free at distant end, and then test again from the actual end of cable, with the distant end to earth. Thus, in the same manner as we procured x, y, z, and R_1, we obtain x_1, y_1, z_1, and R_2, and so on until we find that $R_n = R_{n-1}$. Results obtained with this insertion will be correct if the test be carefully taken.

On board ship I prefer to use a Wheatstone bridge, and shall consider a case in which an even bridge in employed. Should it be deemed advisable to use a dividing bridge, the necessary slight alteration in formula will, of course, suggest itself.

We first take simple "Blavier" as before, and obtain from the same approximations x, y, and z.

Let a = E.M.F. of battery ;
,, r = resistance of battery ;
,, r'' = ,, in either side of bridge ;
,, R, R_a, R_b, &c. = resistance unplugged when equilibrium is obtained with distant end free ;
,, R', R'^a, R'^b, &c. = resistance unplugged when equilibrium is obtained with distant end to earth ;
,, R_1, R_2, R_3, &c. = first, second, third, &c., approximations in ohms to resistance which must be inserted when testing line free at distant end, R_n being correct insertion.

Then, when distant end is free,

$$\frac{a}{r + \frac{r'' + R}{2}} = \frac{a}{c} = \text{current through fault ;}$$

and when distant end is to earth

$$\frac{a}{r + \frac{r'' + R'}{2}} = \frac{a}{d} = \text{current through "}x\text{."}$$

In the same manner as before we now find quantity of $\frac{a}{d}$ flowing through fault. Let this quantity $= \frac{a}{e}$, then R_1 will equal $2\,(e - c)$.

Having now obtained R_1 we proceed as before to obtain x', y', z', always testing, of course, from the actual end of cable when distant end is to earth. We must proceed until insertion represented by R_n = that represented by R_{n-1}.

I may hint with possible advantage to some readers that it is an excellent plan to make up a Wheatstone bridge of cable when practicable, especially in cases when the resistance to the fault is small, and when the fault is of such a nature as to require the application of a powerful electromotive force. In cases where the fault is considerably nearer to one end, tests should be taken from that end if possible. In the case of a high resistance fault near the distant end of the line, R_1, R_2, &c., might at times be so high as to seriously interfere with the sensitiveness of the test ; in such cases the E.M.F. must be altered. Should we find that additional inserted resistance makes no difference in result, we shall be safe, of course, in accepting such result as correct. As in every instance in which I have employed this method it has given me great satisfaction, I now publish it in the hope that others may find it as useful to them as it has proved to me.

Shortly after 10 o'clock the result of the balloting for members' and associates' representatives on the Council was announced, when the following gentlemen were declared to be elected :—

President : Prof. D. E. Hughes, F.R.S.

Vice-Presidents : Sir Charles Bright, M.Inst.C.E. ; Edward Graves ; Colonel Sir Francis Bolton, J. Hopkinson, M.A., D.Sc., F.R.S.

Ordinary Members of Council : William T. Ansell, F.R.G.S. ; Prof. W. E. Ayrton, F.R.S. ; E. B. Bright, M.Inst.C.E. ; R. E. Crompton, M.Inst.C.E. ; William Crookes, F.R.S. ; Prof. George Forbes, M.A., F.R.S.E. ; Alexander Siemens, Augustus Stroh, Captain Philip Cardew, R.E. ; J. A. Fleming, M.A., D.Sc. ; Prof, John Perry, F.R.S. ; Prof. Silvanus P. Thompson, B.A., D.Sc., F.R.A.S.

Associate Members of Council : W. Lant Carpenter, B.A., B.Sc.; Gisbert Kapp, John Munro.

Honorary Treasurer : Edward Graves.

Honorary Secretary : Colonel Sir Francis Bolton.

Auditors : J. Wagstaff Blundell (Wagstaff Blundell and Co., chartered accountants, 12, Delahay-street, Westminster); Frederick C. Danvers, India Office, S.W.

Honorary Solicitors : Messrs. Wilson, Bristows, and Carpmael, 1, Copthall-buildings, E.C.

LIGHTHOUSE ILLUMINANTS.—ELECTRIC LIGHT APPARATUS.

REPORT OF PROF. W. GRYLLS ADAMS, F.R.S., &c.

(Continued from page 98.)

Photometric Observations in Hut 2.

The photometric observations in hut 2 were made by means of the achromatic lens of 7·593 ft. focal length, and the Bunsen photometer, the light concentrated by the lens being compared with the light from the Douglass standard lamp. The Douglass standard was a large colza oil lamp with a slit used as a Methven slit, and which could be made of any convenient size, according to the brightness of the light to be compared with it. This Douglass standard, as used on November 8th and November 10th, in No. 2 hut, was compared with the pentane gas flame on the morning of November 10th in the photometric gallery, and the result of a long series of comparisons gave the light of the Douglass lamp as 3·166 candles.

The pentane flame and the Douglass standard were compared directly by means of the Bunsen disc or the star disc without any absorbing medium.

Ruby glass and a solution of ammonia sulphate of copper placed before the eye were also employed, so as to compare the intensities of red and blue light in the two sources of light.

The readings as taken for red or blue differed by less than ·57 per cent., showing that these sources gave light nearly of the same quality or colour, and so may be properly compared for illuminating power without employing any medium in front of the eye to enable the observer to judge when he has equal illumination on the two sides of the disc.

On the evening of November 8th, 1884, the achromatic lens was arranged in hut 2. so as to compare the lights from the towers with the Douglass standard lamp.

Two sets of experiments were made :—

(1.) The lens was fixed as at A in Fig. 4. The star disc fixed at B, a distance of 3·38 ft. from A. The focal length of the lens 7·593 ft. C is the focus of the lens. The Douglass standard D was moved to and fro until a balance of light on the disc was obtained.

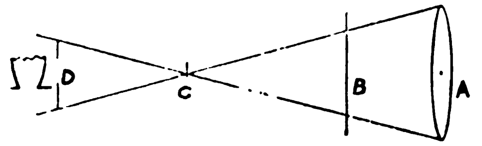

Fig. 4.

The points of disappearance of the star on the two sides were noted, and the mean of these points was taken as the position corresponding to the equality of the lights.

Ruby glass was used in front of the eye of the observer when measuring the electric light.

Hence, in these values the more refrangible rays, which are so abundant in the electric light, making it so much whiter than gas or oil, are neglected.

Measurements were made of the illumination from the single six-wick oil light with the Mew Island lens. The mean of the results obtained for the illumination at the focus was ·02337 candle, so that the illumination at hut 2 was ·000573 candle. This illumination would be given at hut 2 by a naked light of 22,030 candles placed on the lighthouse tower if there were no absorption by the atmosphere. The intensity of the naked light which, radiating in all directions from the lighthouse tower, would give the illumination measured at hut 2, is in each case given in brackets thus (22,030). The disc was then removed 2 ft. 6 in. nearer to the focus, so that it was at a distance of 1·71 ft from the focus. The measurements now gave an illumination of ·0227 candle at the focus, or ·000557 at hut 2 (21,410). Measurements were then made of the Wigham single 108-jet gas burner with the disc in the same position, when the illumination at the focus was found to be ·0235 candle, which gives an illumination of ·000576 at hut 2 (22,140).

Evening of November 10th. The observations of the electric current were made by the electro-dynamometer in the engine room, and the electromotive force was measured both between the terminals of the machines in the engine room and between the extremities of the arc in the "A" tower by means of two Cardew voltmeters.

The lamp employed was a new De Meritens lamp, which was used for the fisrt time. It was placed on the lowest stage in the "A" tower, and the lens employed was the cylindrical lens with vertical prisms. Observations on the illuminating power were made by me during the latter part of the evening in No. 2 hut, the current and electromotive force being measured during the same period by two of my students, one in the engine room, the other in the "A" tower.

Throughout the evening (the observations extended over about 2½ hours) the current and the electromotive force remained remarkably steady, for out of more than 50 observations of the current, there is no single observation below 112 amperes or above 125 amperes, and usually a slight increase of current is accompanied by a slight diminution of electromotive force, such as might be expected from a very slight change in the length of the arc.

The average number, obtained by multiplying the average E.M.F. by the

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average current, gave 5,760 watts as the work expended per second in the external circuit, and 3,480 watts expended in the arc, the difference, viz., 2,280 watts, being expended in overcoming the resistance of the leads to the "A" tower. The E.M.F. between the extremeties of the arc was 29 volts, and between the terminals of the machines 48 volts.

On the evening of November 10th, 1884, a new De Meritens lamp was tried in the lower stage of the "A" tower with the cylindrical lens with the vertical prisms, and observations of the intensity of the light were made in No. 2 hut. The E.M.F. at the extremities of the arc was 29 volts, and the average current 120 amperes.

On this evening, when the new lamp was being tried in the "A" tower with the cylindrical lens and vertical prisms, I made measurements of the illumination given at hut 2 by the following method :—

The achromatic lens A (Fig. 4) was fixed in position, and the Douglass standard D was fixed at a distance of 7·96 ft. beyond the focus of the lens. The photometer disc B was moved to and fro on the stand between the focus C and the Douglass lamp.

This arrangement was more satisfactory than the arrangement of November 8th, and a very consistent set of measurements was obtained.

The mean value of the readings gave 5·5 ft. and 2·46 ft. as the distances of the disc from the Douglass standard, and from the focus of the achromatic lens respectively. Hence the illumination at the focus equalled ·633 candle, and the illumination at hut 2 was ·0155 candle (595,800).

At another period of the evening, the Bunsen disc was fixed at a distance of 3·38 ft. from the lens, as in the experiments on November 8th, and the Douglass standard was moved to and fro to balance the illumination on the disc. The measurements were now higher and the illumination was 1·933 candle at the focus, or ·0474 candle at hut 2 (1,823,000).

On the evening of December 17th, I made experiments on the three machines supplying current to the "A" tower, whilst Mr. Dixon was measuring the illumination given through the cylindrical lens with vertical prisms in No. 1 hut.

With one machine, from 7:30 to 8:30, the electromotive force at the terminals of the machine was 51 volts, and the average current was 133 amperes, giving about 6,750 watts at 600 revolutions.

With two machines to one arc, using the 40 mm. Berlin core carbons, the E.M.F. was 60 volts, and the current 172 amperes, giving 10,330 watts.

The illumination at hut 1 from one arc with the current from two machines in parallel circuit varied from about $\frac{1}{4}$th of a candle to $\frac{1}{6}$th of a candle from 8:45 to 9 p.m. (770,300 to 1,155,000), and amounted to $\frac{1}{3}$rd of a candle about 9:30 p.m. The two machines were then joined in series to supply two arcs in series in the "A" tower, when the E.M.F. was 82 volts and the current 158·4 amperes, giving 13,000 watts in the circuit; and the light from the two arcs gave an illumination in No. 1 hut of from $\frac{1}{3}$rd to $\frac{4}{10}$ths of a candle (1,540,000 to 1,849,000).

From 10 to 10:15 p.m., the three machines were driven, and supplied one arc in the "A" tower, giving an E.M.F. of 65 volts and a current of 160 amperes, *i.e.*, the three give no greater current through a single arc in "A" tower than the two machines in tension through two arcs in series.

Now, on throwing the belt off the third machine and driving that as a motor by means of the current from the other two machines, the E.M.F. remains nearly the same, 65 volts, but the current increases to 170 amperes, and the steadiness of working of the machines is increased. This entirely confirmes the experiments of November 10th, when two machines driving the third as a motor were found to do more work in the arc, and to produce more light, than the two machines alone, or than the three machines when all were separately driven by the engine.

From 10:30 to 11:30 p.m. experiments were made to see what was the amount of loss by the leads when using three machines together and with both De Meritens 81 square carbons and the Siemens 40 mm. Berlin core carbons.

(1.) With the De Meritens carbons and with the third machine as a motor, of the 66 volts no less that 30·4 volts are lost on the leads, and only 35·6 volts are useful in the arc, *i.e.*, $46\frac{2}{3}$ per cent. of the energy given out by the machines is lost on the leads. With the three machines, all driven direct by the engine, of the 65 volts in the circuit, 29·5 volts are spent in the leads and 35·5 volts on the single arc, or 45·4 per cent. of the energy produced is spent on the leads.

(2.) With the 40 mm. Berlin core carbons, it was found that with the same E.M.F. the current was greater than with the De Meritens 81 square carbons, being 175 amperes as against 162 amperes.

Also with the Berlin core carbons, when the third machine was driven as a motor by the current from the other machines, the current was increased from 175 amperes to 188 amperes. This is the largest current which, I believe, has ever been supplied to the "A" tower.

Thus it appears that of the energy which might be produced from two machines, only one-fourth, or 25 per cent, has been actually produced in the "A" tower by any arrangement of the machines, and that with present arrangements it is impossible to obtain more than this.

On the evening of December 18th, the separate machines and two machines parallel and two machines in tension were again tried, as on the evening of December 17th, and Mr. Dixon was measuring the illuminating power of the light.

The results quite confirm the observations of December 17th.

Two single machines L No. 1 and L No. 2 were tried separately, when it appeared that at the same electromotive force, 52 volts, L No. 1 gave a current of 136·7 amperes and L No. 2 gave a current of 131·4 amperes.

These machines were then joined in parallel circuit to supply a single arc in the "A" tower, and gave an E.M.F. of 64 volts and 171 amperes, a little higher E.M.F. than on the previous evening, and the illuminating power was also somewhat higher, going up to ·435 candle, and even to nearly $\frac{5}{10}$ths of a candle, the distance of No. 1 hut being 2,150 feet from the towers (2,010,000 to 2,773,000).

The machines were then joined in series to supply two arcs (biform) in series, when the electromotive force was 85 volts and the current 102·4 amperes, as compared with 82 volts and 158·4 amperes on the previous evening.

Experiments of January 23rd, and Observations of Illumination at Hut 2.

The method which I had adopted on November 10th was employed in hut 2 by Mr. Dixon to determine the illuminating power of the various lights, whilst I measured the E.M.F. and current in the engine room.

The Douglass lamp was fixed, and the star disc was moved to and fro, between the focus of the lens and the Douglass standard.

The lens employed at first in the "A" tower was the cylindrical belt with vertical prisms.

The Douglass standard was measured by me next morning in the photometric gallery, and found to be ·535 candle; and about two hours afterwards was again measured by Mr. Dixon, and found to be ·535 candle.

As the evening was hazy, and the haze was not uniform throughout the evening, only those observations which were taken about the same time are comparable with one another.

With the two machines supplying a current of electricity to a single arc in the "A" tower, the electromotive force was 60 volts and the current 186·7 amperes, giving 11,200 watts. The illumination at the focus of the lens in hut 2 was ·3617 candle and the illumination at the distance of hut 2 was ·00887 candle (341,000).

In the second set of experiments with two machines, the electromotive force was 61 volts and the current 175 amperes, giving 10,675 watts; and the illumination at focus of the lens in hut 2 was 2358 candle, giving an illumination of ·005784 candles at hut 2 (222,300).

With a single machine supplying current to one arc in the "A" tower, the electromotive force was 50 volts and the current 146·3 amperes, giving 7,315 watts, and the intensity of illumination at the focus was ·1531 candle, giving ·004024 candle at distance 6,200 feet (154,600).

The light from one arc supplied by one machine with the Mew Island lens was also measured in No. 2 hut. The average E.M.F. was 51 volts, and the current 144 amperes, *i.e.*, very nearly the same as before; and the illumination at the focus was 3·646 candles or ·0894 candle at hut 2 (3,437,000).

On comparing this light with the Wigham 108-jet gas it was found that during the early part of the evening the single 108-jet gas gave an illumination at the focus of ·01172 candle (11,050); that later on it gave an illumination of ·009036 candle (8,517) at the focus of the lens, and the Wigham quadriform (108 jet) gas gave an illumination of ·03583 candle (33,780).

Hence it appears that on a hazy night the single electric light with the cylindrical lens and vertical prisms gave an illumination equal to 14 times the Wigham 108-jet gas with the Mew Island lens.

On February 27th and 28th, and again on March 6th and 7th, experiments were tried and measurements made with the electric light placed nearer to the M.I. lens by 2 inches, 4 inches, and 8 inches than the focal length of the lens in order to measure the intensity of ex-focal light.

Comparison was made once or twice during the evening with the illumination given by cylindrical lens with vertical prisms or V.P., in order to compare with what the illumination would be when the arc was in the focus of the M.I. lens.

Experiments were also made with the arc raised 2 or more inches above, and depressed 2 or more inches below the focal plane.

The object of these experiments was to determine the intensity in various parts of the diverging electric beam when the light was placed nearer to the lens than its principal focus. This may give some idea of the loss of light from the parts of any burner which are out of focus, and which, therefore, give ex-focal light.

Take, first, the relative values of the illumination given by the M.I. lens with arc in focus, and by the cylindrical lens with vertical prisms with arc in focus.

A determination by myself on February 28th, gave the ratio of lights from M.I. lens to V.P. as 12 to 1.

A determination by Mr. Longford the same evening, also gave the ratio of M.I. lens to V.P. as that of 12 to 1.

A determination by Mr. Hall on March 5th, gave the ratio of M.I. lens to V.P. as 12·8 to 1.

A determination by Mr. Dixon on March 3rd, also gives the ratio about 12·1 to 1.

Hence we may assume that for an observer at a distance the magnifying power of the M.I. lens is 12 times the magnifying power of the cylindrical lens with vertical prisms.

Theoretical Discussion.

Method of using the Hopkinson photometer with the Douglass standard lamp :—

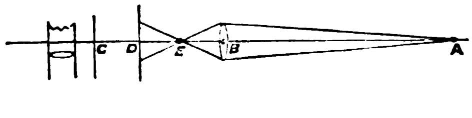

Fig. 5.

Let C be the position of the slit in front of the Douglass standard.

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D the position of the Bunsen or star disc.
B the lens of the Hopkinson photometer.
E the conjugate focus to A, which is the source of light. Let A B = u, E B = v, and f the focal length of the lens.

Then the illumination of D is the same as if E were the source of light. The intensity at—

$$E=\frac{1}{c}\times L\times\frac{B\,E^2}{A\,B^2}=\frac{1}{c}\cdot L\times\frac{v^2}{u^2}=\frac{L}{c}\left(\frac{f}{u-f}\right)^2$$

where $\frac{1}{c}$ is the coefficient of absorption of the lens.

Hence if λ be the intensity of the standard at c—

$$\text{then }\frac{c\,\lambda}{C\,D^2}=\frac{L\times f^2}{E\,D^2\times(u-f)^2}$$

$$\text{or } L=c\,\lambda\left(\frac{E\,D}{C\,D}\right)^2\times\left(\frac{u-f}{f}\right)^2$$

The values of E D and C D were read off on a scale, if d be the reading for the slit C, r the reading for the disc, and a the reading for the image E,

$$\text{then } L=\lambda\left(\frac{r-a}{d-r}\right)^2\times\frac{c}{f^2}\times(u-f)^2.$$

The value of $c=1{\cdot}083$ and $f=1{\cdot}933$in. = ·161ft. for the Hopkinson lens.

Method of Measuring Lights at a Distance.

1. When a lens, such as a lighthouse lens, is placed in the path of the beam so as to have the point A, the source of light, accurately at its principal focus, then the rays between the two lenses are parallel to the axis, and if f_1 be the focal length of the lighthouse lens, the intensity at A is—

$$L=\lambda\left(\frac{r-a}{d-r}\right)^2\times\frac{c}{f^2}\times c_1 f_1^2.$$

If, in addition, the absorption of light by the atmosphere is taken into account, and if a be its coefficient of transparency,

$$\text{then } L=\lambda\left(\frac{r-a}{d-r}\right)^2\times\frac{c}{f^2}\times c_1 f_1^2\times\frac{1}{a^l}$$

when l is the distance between the two lenses.

(To be continued.)

ELECTRIC LIGHT LICENSE.

(Concluded from page 97.)

11. The Undertakers may from time to time alter the position of any pipes or wires, being under any street or place authorised to be broken up by them, which may interfere with the exercise of their powers under the principal Act or this License; and any body or person may in like manner alter the position of any electric lines or works of the Undertakers, being under any such street or place as aforesaid, which may interfere with the lawful exercise of any powers vested in such body or person in relation to such street or place, subject to the following provisions unless otherwise agreed between the parties interested:—

(*a.*) One month before commencing any such alteration the Undertakers, or such body or person (as the case may be), in this section referred to as "the operators," shall serve a notice upon the body or person for the time being entitled to such pipes, wires, electric lines, or works (as the case may be), in this section referred to as "the owners," describing the proposed alteration, and stating the amount of compensation proposed to be made in respect thereof, and the manner in which such compensation is proposed to be paid or secured, together with a plan showing the manner in which it is intended that such alterations shall be made, and shall, upon being required to do so by any such owners, from time to time give them any such further information in relation thereto as they may desire.

(*b.*) Within three weeks after the service of any such notice and plan upon any owners, such owners may, if they think fit, serve a requisition upon the operators requiring that any question in relation to such works and any other question arising upon such notice or plan as aforesaid shall be settled by arbitration; and thereupon such question shall be settled by arbitration accordingly.

(*c.*) In settling any question under this section an arbitrator shall have regard to any duties or obligations which the owners may be under in respect of such pipes, wires, electric lines, or works, and may, if he thinks fit, require the operators to execute any temporary or other works so as to avoid interference with any purpose for which such pipe, wire, electric line, or work is used so far as may be possible.

(*d.*) Where no such requisition as in this section mentioned is served upon the operators, the owners shall be held to have agreed to the notice or plan served on them as aforesaid, and in such case, or where, after any such requisition has been served upon them, any question required to be settled by arbitration has been so settled, the operators upon paying or securing any compensation which they may be required to pay or secure in the manner proposed by them or settled by arbitration as aforesaid, may cause the alterations specified in such notice and plan as aforesaid to be made, but subject in all respects to the provisions of this License and the principal Act, and only in accordance with the notice and plan so served by them as aforesaid, or such modifications thereof respectively as may have been settled by arbitration as hereinbefore mentioned, or as may be agreed upon between the parties.

(*e.*) At any time before any operators are entitled to commence any such alterations as aforesaid the owners may serve a statement upon them, stating that they desire to execute such alterations themselves, and where any such statement has been served upon the operators they shall not be entitled to proceed themselves to execute such alterations except where they have notified to such owners that they require them to execute such alterations, and such owners have refused or neglected to comply with such notification as hereinafter provided.

(*f.*) Where any such statement as last aforesaid has been served upon the operators, they shall, not more than forty-eight hours and not less than twenty-four hours before the execution of such alterations is required to be commenced, serve a notification upon the owners stating the time when such alterations are required to be commenced, and the manner in which such alterations are required to be made.

(*g.*) Upon receipt of any such notification as last aforesaid, the owners may proceed to execute such alterations as required by the operators, subject to the like restrictions and conditions as the operators would themselves be subject to in executing such alterations so far as the same may be applicable.

(*h.*) If the owners decline, or for twenty-four hours after the time when any such alterations are required to be commenced, neglect to comply with such notification, the operators may themselves proceed to execute such alterations in like manner as they might have done if no such statement as aforesaid had been served upon them.

(*i.*) All expenses properly incurred by any owners in complying with any notification of any operators under the last preceding sub-sections shall be repaid to them by such operators.

(*j.*) Any owners may, if they think fit, by any statement served by them upon any operators under this section, require the operators to give them such security for the repayment to them of any expenses to be incurred by them in executing any alterations as above mentioned as may be agreed upon between such owners and operators, or in default of agreement as may be determined by arbitration, and where any operators have been so required to give security they shall not be entitled to serve a notification upon the owners requiring them to execute any alterations until such security has been duly given.

(*k.*) If the operators make default in complying with any of the requirements or restrictions of this section they shall (in addition to any other compensation which they may be liable to make under the provisions of this License or the principal Act) make full compensation to the owners affected thereby for any loss, damage, or penalty which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding ten pounds for every such default, and in the case of a continuing offence to a further penalty not exceeding five pounds for every day after the first day during which such default continues; provided that the operators shall not be subject to any such additional penalties as aforesaid if the Court having cognizance of the case are of opinion that the case was one of emergency, and that the operators complied with the requirements of this section so far as was reasonable under the circumstances.

12. Whenever the Undertakers require to dig or sink any trench for laying down any new electric lines (other than service lines) or other works near to which any pipe belonging to any gas or water company, or any branch or service pipe for the supply of gas or water has been lawfully placed, or where any gas or water company require to dig or sink any trench for laying down any new mains or pipes other than service pipes or other apparatus near to which any electric lines or works of the Undertakers have been lawfully placed, the Undertakers or such gas or water company (as the case may be), in this section referred to as "operators," shall, unless otherwise agreed between the parties interested, give to such gas or water company, or to the Undertakers (as the case may be), in this section referred to as "the owners," not more than forty-eight hours and not less than twenty-four hours' notice before commencing to dig or sink such trench as aforesaid, and such owners shall be entitled by their officers to superintend the digging or sinking of such trench, and the operators shall conform with such reasonable requirements as may from time to time be made by the owners or any such officer for the protection of every such pipe, electric line, or work, and for securing the same from injury, and they shall also, if required to do so by the owners thereof, repair any damage that may be done thereto.

If the operators make default in complying with any of the requirements or restrictions of this section, they shall make full compensation to the owners of any pipe, electric line, or work affected thereby for any loss or damage which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding ten pounds for every such default, and in the case of a continuing offence to a further penalty not exceeding five pounds for every day after the first day during which such default continues: Provided that the operators shall not be subject to any such penalty if the Court having cognizance of the case are of opinion that the case was one of emergency and that the operators complied with the requirements and restrictions of this section so far as was reasonable under the circumstances, or that the default in question was due to the fact that the operators were ignorant of the position of the pipe, electric line, or work affected thereby, and that such ignorance was not owing to any negligence on the part of the operators.

For the purposes of this section the expression "gas or water company" shall include any body or person supplying gas or water.

13. Seven days before commencing to lay down any electric line, or to supply electricity through any electric line in any manner whereby the work of telegraphic or telephonic communication through any wires or lines lawfully laid down or placed in any position may be injuriously effected, the Undertakers shall, unless otherwise agreed between the par-

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ties interested, give to the body or person for the time being entitled to such wires or lines notice in writing specifying the course, nature, and gauge of such electric lines, and the amount and nature of the current intended to be sent along the same, and the extent to and manner in which, if at all, earth returns are proposed to be used; and the Undertakers shall conform with such reasonable requirements as may from time to time be made by such body or person as aforesaid for the purpose of preventing communication through such wires or lines from being injuriously affected as aforesaid.

If any difference arises between any such body or person and the Undertakers with respect to the reasonableness of any requirements so made, such difference shall be determined by arbitration.

Provided that nothing in this section shall apply to repairs or renewals of existing electric lines so long as the character and position thereof is not altered, nor to the laying of connections with mains where the direction of the electric line so laid down crosses the direction of the said telegraphic or telephonic wires or lines at right angles at the point of shortest distance, and such directions continue the same for a distance of 6ft. on each side of such point.

If the Undertakers make default in complying with any of the requirements or restrictions of this section they shall make full compensation to the body or person entitled to any such wire or line as aforesaid for any loss or damage which they may incur by reason thereof, and in addition thereto they shall be liable to a penalty not exceeding five pounds for every such default, and in the case of a continuing offence to a further penalty not exceeding forty shillings for every day after the first day during which such default continues: Provided that the Undertakers shall not be subject to any such penalties as aforesaid if the Court having cognizance of the case are of opinion that the case was one of emergency, and that the Undertakers complied with the requirements and restrictions of this section so far as was reasonable under the circumstances, or that the default in question was due to the fact that the Undertakers were ignorant of the position of the wires or lines affected thereby, and that such ignorance was not owing to any negligence on the part of the Undertakers.

Maps.

14. The Undertakers shall forthwith, after commencing to supply electricity under this License cause a map to be made of the area of supply on such a scale as may from time to time be prescribed by the Board of Trade, and shall cause to be marked thereon the line of all their then existing mains, service lines, and other underground works and distributing boxes, and shall once in every year cause such map to be corrected and such additions to be made thereto as will show the line of all their then existing mains, service lines, and other underground works and distributing boxes.

15. Every map so made or corrected for the Undertakers, or a copy thereof, with the date expressed thereon of the last time when it was so corrected, shall be kept by the Undertakers at their office, and a copy of every such map shall within one month after such map is made or corrected be served by the Undertakers upon the Board of Trade and upon the Postmaster-General, and where the Local Board are not themselves the Undertakers upon the Local Board, and any copy so served upon the Local Board shall be kept by them at their office.

Every map or copy kept by the Local Board at their office under the provisions of this section, shall at all reasonable times be open to the inspection of all applicants, and such applicants may take copies of the same or any part thereof.

The Local Board may demand and take from every such applicant as aforesaid such fee not exceeding one shilling for each inspection of such map or copy, and such further fee not exceeding one shilling for each copy of the same, or any part thereof, taken by such applicant, as they may from time to time prescribe.

16. If the Undertakers fail to comply with any of the requirements of the last preceding sections of this License with respect to maps, they shall for every such offence be liable to a penalty not exceeding £10 and to a further penalty not exceeding £2 for every day after the first day during which such offence continues.

Testing.

17. The Undertakers shall, if and when required to do so by the Board of Trade from time to time, at their own cost, provide such reasonable number of testing places and provide and keep in efficient working order such suitable instruments at such testing places and upon any premises from which they supply electricity through any distributing mains for the purposes of general supply, and take and record such observations and give such facilities for the testing of the supply of electricity given by them, and the mains electric lines and works used by them for the purposes of such supply, by such persons as may be directed by the Board of Trade, and in default of so doing, they shall be liable to a penalty not exceeding five pounds for every such default, and in the case of a continuing offence to a further penalty not exceeding one pound for every day after the first day during which such offence continues.

18. If at any time it appears to the Board of Trade that any mains, electric lines, or works, of the Undertakers are defective and not in accordance with the regulations and conditions subject to which the Undertakers are for the time being authorised to supply electricity under this License, the Board of Trade may by order in writing require the Undertakers to remedy such defect so as to comply with such regulations and conditions within such period as may be therein limited in that behalf, and if the Undertakers make default in remedying such defect within the time so limited, they shall be liable to a penalty not exceeding twenty pounds for every day during which such default continues. Provided that if such defect is in the opinion of the Board of Trade dangerous to public safety, they may also, by any such order as aforesaid, forbid the use of such main, electric line, or work as from such date as may be specified in that behalf until the defect is remedied, and if the Undertakers make use of any such main, electric line, or work, while the use thereof is so forbidden, they shall be liable to a penalty not exceeding one hundred pounds for every day during which such user continues.

Supply.

19. The Undertakers shall, upon being required so to do at any time within six years after the commencement of this License, by the owner or occupier of any premises situated within twenty-five yards from any distributing main of the Undertakers, in which they are for the time being required to maintain a current of electricity for the purposes of general supply under this License or any regulations or conditions subject to which they are authorised to supply electricity under this License, give and continue to give a supply of electricity for such premises, in accordance with the provisions of this License, and of all such regulations and conditions as aforesaid, and they shall furnish and lay any electric lines that may be necessary for the purpose of supplying the maximum current with which any such owner or occupier may be entitled to be supplied under this License, subject to the conditions following; (that is to say),

The cost of so much of any electric line for the supply of electricity to any owner or occupier as may be laid upon the property of such owner or in the possession of such occupier, and of so much of any such electric line as may be laid for a greater distance than thirty feet from any distributing main of the Undertakers, although not on such property, shall be defrayed by such owner or occupier.

Every owner or occupier of premises requiring a supply of electricity shall—

Serve a notice upon the Undertakers at their office, specifying the premises in respect of which such supply is required and the maximum current required to be supplied, and the day (not being an earlier day than a reasonable time after the date of the service of such notice) upon which such supply is required to commence:

Enter into a written contract with the Undertakers (if required by them so to do) to continue to receive and pay for a supply of electricity for a period of at least two years, or for a residue of the term of this License where such residue is less than two years, of such an amount that the rent payable for the same, at the rate of charge for the time being charged by the Undertakers for a supply of electricity to ordinary consumers within the area of supply, shall not be less than twenty pounds per centum per annum on the outlay incurred by the Undertakers in providing any electric line to be provided by them for the purpose of such supply, and give to the Undertakers (if required by them so to do) reasonable security for the payment to them of all moneys which may from time to time become due to them by such owner or occupier in respect of any electric lines to be furnished by the Undertakers, and in respect of electricity to be supplied by them.

Provided always, that the Undertakers may, after they have given a supply of electricity for any premises, by notice in writing require the owner or occupier of such premises, within seven days after the date of the service of such notice, to give to them such reasonable security as aforesaid, in case such owner or occupier has not already given such security, or in case any security given has become invalid or is insufficient; and where any such owner or occupier fails to comply with the terms of such notice, the Undertakers may, if they think fit, discontinue to supply electricity for such premises so long as such failure continues.

Provided also that if the owner or occupier of any such premises as aforesaid uses any form of lamp or burner, or uses the electricity supplied to him by the Undertakers for any purpose or deals with it in any manner so as to unduly or improperly interfere with the supply of electricity to any other body or person by the Undertakers, the Undertakers may, if they think fit, discontinue to supply electricity to such premises so long as such user continues.

If any difference arises between any such owner or occupier and the Undertakers as to the reasonableness of the amount of any security required to be given or as to the sufficiency of any security offered under this section such difference shall be determined by arbitration.

20. The maximum current with which any such consumer, as in the last section mentioned, shall be entitled to be supplied shall be of such amount as he may from time to time require to be supplied with, not exceeding what may be reasonably anticipated as the maximum consumption on his premises: Provided that where any consumer has required the Undertakers to supply him with a maximum current of any specified amount, he shall not be entitled to alter that maximum except upon one month's notice to the Undertakers, and any expenses incurred by the Undertakers in respect of the service lines by which electricity is supplied to the premises of such consumer, or any electric lines, fittings, or apparatus of the Undertakers upon such premises, consequent upon such alteration, shall be paid by him to the Undertakers.

If any difference arises between any such owner or occupier and the Undertakers as to what may be reasonably anticipated as the consumption on his premises such difference shall be determined by arbitration.

21. Whenever the Undertakers make default in giving a supply of electricity to any owner or occupier of premises in accordance with the terms of this License and of any regulations and conditions subject to which they are authorised to supply electricity under this License, they shall be liable to a penalty not exceeding forty shillings in respect of every such default for each day upon which any such default occurs.

Provided that the penalties to be inflicted on the Undertakers under this section shall in no case exceed in the aggregate the sum of one hundred pounds in respect of any defaults in supplying private consumars for any one day, and provided also that in no case shall any penalty be inflicted in respect of any default if the Court having cognizance of the case should be of opinion that such default was caused by inevitable acci-

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dent or by force majeure, or was of so slight or unimportant a character as not materially to affect the value of the supply.

Price.

22. The Undertakers may charge for electrictity supplied by them from any distributing main to any ordinary consumer (otherwise than by agreement)—

(1.) By the quantity of energy contained in such supply; or,

(2.) By the actual quantity of electricity so supplied; or,

unless the Board of Trade from time to time otherwise direct,

(3.) By the number of hours during which the supply of electricity is actually used by such consumer, and the maximum current with which he is for the time being entitled to be supplied:

Provided that before commencing to supply electricity through any distributing main for the purposes of general supply, the Undertakers shall give notice to all consumers into whose premises service lines have been laid from such main by what method they propose to charge for electricity supplied through such main; and, where the Undertakers have given any such notice, they shall not be entitled to change such method of charging except after one month's notice of such change has been given by them to every consumer of electricity who is supplied by them from such main.

23. The prices to be charged by the Undertakers for electricity supplied by them shall not exceed those stated in that behalf in Schedule A in the first, second, and third sections thereof respectively.

24. Subject to the provisions of this License and of the principal Act, and to the right of the consumer to require that he shall be charged according to some one or other of the methods above mentioned in cases where he is entitled to require a supply, the Undertakers may make any agreement with a consumer as to the price to be charged for electricity, and the mode in which such charges are to be ascertained, and may charge accordingly.

Application of Revenue.

25. All moneys from time to time received by the Local Board in respect of the undertaking, except borrowed money, shall be applied by them as follows:—

(1.) In payment of the working and establishment expenses and cost of maintenance of the undertaking, including all costs, expenses, penalties, and damages incurred or payable by the Local Board, consequent upon any proceedings by or against the Local Board, their officers or servants, in relation to the undertaking.

(2.) In payment of the interest on any mortgages, stock, or other securities granted and issued by the Undertakers in respect of money borrowed for electricity purposes.

(3.) In providing any instalments or sinking fund required to be provided in respect of moneys borrowed for electricity purposes.

(4.) In payment of all other their expenses of executing this License, not being expenses properly chargeable to capital.

And shall carry the net surplus remaining in any year to the credit of the local rate as defined by the Electric Lighting Act, 1882.

Any deficiency of income in any year shall be charged upon and payable out of the local rate aforesaid.

Notices, &c.

26. Notices, orders, and other documents under this License may be in writing or in print, or partly in writing and partly in print; and where any notice, order, or document requires authentication by the Local Board, the signature thereof by the clerk or surveyor to the Local Board shall be sufficient authentication.

27. Any notice, order, or document required or authorised to be served upon any body or person under this License, or the principal Act, may be served by the same being addressed to such body or person and being left at or transmitted through the post to the following addresses respectively:—

(*a.*) In the case of the Board of Trade, the office of the Board of Trade;

(*b.*) In the case of the Postmaster-General, the General Post Office;

(*c*) In the case of the Local Board, the office of the Local Board or their clerk;

(*d.*) In the case of the justices of the peace for any county, the office of the clerk of the peace for the said county;

(*e.*) In the case of any company having a registered office, the registered office of such company;

(*f.*) In the case of a company having an office or offices, but no registered office, any such office;

(*g.*) In the case of any other person, the usual or last known place of abode of such person.

Where any notice is served by post it shall be deemed to have been served at the time when the letter containing the notice would be delivered in the ordinary course of post, and in proving such service it shall be sufficient to prove that the letter containing the notice was properly addressed and put into the post.

A notice, order, or document by this License required or authorised to be served on the owner or occupier of any premises shall be deemed to be properly addressed if addressed to the "owner" or "occupier" of the premises (naming the premises), without further name or description.

A notice, order, or document by this License required or authorised to be served on the owner or occupier of any premises may be served by delivering the same, or a true copy thereof, to some person on the premises, or if there is no person on the premises to whom the same can with reasonable diligence be delivered, by fixing the notice on some conspicuous part of the premises.

Expiration or Revocation of License.

28. In addition to any other powers which the Board of Trade may have in that behalf, they may revoke this License at any time with the consent and concurrence of the Undertakers, and also where the Local Board are not themselves the Undertakers of the Local Board, upon such terms as the Board of Trade may think fit.

29. If the Board of Trade at any time revoke this License as to the whole or any part of the area affected thereby, under any of the provisions of this License, the Board of Trade shall serve a notice of such revocation upon the Undertakers, and where the Local Board are not themselves the Undertakers upon the Local Board, and shall in such notice fix a date at which such revocation shall take effect, and from and after such date all the powers of the Undertakers and the Local Board for the supply of electricity under this License within such area, or part thereof as aforesaid, shall absolutely cease and determine.

30. Except so far as may be otherwise specially provided by any license, order, or special Act to be hereafter granted or passed, upon the expiraiion of the term of this License, or upon the revocation of this License as to the whole or any part of the area affected thereby, any body or person who may be liable to repair any street or part of a street within such area or part thereof in which any works of the Undertakers may have been placed, may forthwith remove such works, with all reasonable care, and the Undertakers shall pay to such body or person such reasonable costs of such removal as may be specified in a notice to be served on the Undertakers by such body or person, or (if so required by the Undertakers, within one week after the service of such notice upon them) as may be settled by arbitration.

If the Undertakers fail to pay such reasonable costs as aforesaid within one month after the service upon them of such notice or the delivery of the award of the arbitrator, as the case may be, such body or person as aforesaid may, without any previous notice to the Undertakers (but without prejudice to any other remedy which they may have for the recovery of the amount), sell and dispose of any such works as aforesaid either by public auction or private sale, and for such sum or sums, and to such body or person as they may think fit; and may, out of the proceeds of such sale, pay and reimburse themselves the amount of the costs so specified or settled as aforesaid, and of the costs of sale, and the balance (if any) of the proceeds of the sale shall be paid over by such body or person to the Undertakers.

Transfer of Undertaking.

31. At any time after the commencement of this License the Local Board may, with the consent of the Board of Trade, transfer all or any part of the powers, duties, and liabilities conferred or imposed upon them by this License, as to the whole or any part of the district, together with any lands or works vested in or belonging to them for the purposes of this License, to any other body or person.

General.

32. The Board of Trade may from time to time upon the application of the Undertakers, and upon such conditions (if any) as the Board of Trade think just, suspend or modify any obligation of the Undertakers with respect to the supply of electricity under this License for any period as to the whole or any part of the area of supply.

33. Where the approval or consent of the Board of Trade is given in any case, or where the Board of Trade makes any order or gives any notice under the provisions of this Licence, such approval or consent shall be signified or such order shall be made or notice given in writing under the hand of one of the secretaries or assistant secretaries of the Board of Trade.

34. All costs and expenses of or incident to any application for the approval or consent of the Board of Trade, including the costs of the tests (if any) which may be required to be made by the Board of Trade for the purpose of determining whether such approval or consent should be given, shall be borne and paid by the applicant or applicants for such approval or consent; provided always that where any approval is given by the Board of Trade to any plan, pattern, or specification, they may require such copies of the same as they may think fit to be prepared and deposited at their office at the expense of the said applicant or applicants, and may from time to time, if they think fit, revoke any approval so given, or permit such approval to be continued subject to such modifications as they may think necessary.

35. Where the Board of Trade, upon the application of the Undertakers, give any approval or suspend or modify any obligation of the Undertakers under this License, or revoke this License as to the whole or any part of the area affected thereby, or where any transfer of any powers, duties, or liabilities under this License has been effected by the Local Board with the consent of the Board of Trade to any other body or person, notice that such approval has been given, or such obligation suspended or modified, or such revocation made, or such transfer effected, shall be published by public advertisement once at least in each of two successive weeks in some one and the same local newspaper by the Undertakers.

36. The Undertakers shall be answerable for all accidents, damages, and injuries happening through the act or default of the Undertakers, or of any person in their employment by reason or in consequence of any of the Undertaker's works, and shall save harmless all other bodies and persons collectively and individually, and their officers and servants, from all damages and costs in respect of such accidents, damages, and injuries.

37. Nothing in this License shall authorise the Undertakers to take, use, or in any manner interfere with any portion of the shore or bed of the sea, or of any river, channel, creek, bay, or estuary, or any right in respect thereof, belonging to the Queen's most Excellent Majesty, in right of her crown, and under the management of the Board of Trade, without the previous consent of the Board of Trade on behalf of Her Majesty (which consent the Board of Trade may give); neither shall anything in this License contained extend to take away, prejudice, diminish, or alter any of the estates, rights, privileges, powers, or authorities vested in, or enjoyed or exercisable by, the Queen's Majesty, her heirs or successors,

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38. The Undertakers shall not construct on the shore of the sea, or of any creek, bay, or arm of the sea, or navigable river communicating therewith, where and so far up the same as the tide flows and re-flows, any work without the previous consent of the Board of Trade, and then only according to such plan and under such restrictions and regulations as the Board of Trade may approve of; and where any such work may have been constructed, the Undertakers shall not at any time alter or extend the same without obtaining previously to making any such alteration or extension the like consents or approvals. If any such work be commenced or completed contrary to the provisions of this License, the Board of Trade may abate and remove the same, and restore the site thereof to its former condition at the cost and charge of the Undertakers.

39. Nothing in this License shall affect any right or remedy of the Postmaster-General under the Electric Lighting Act, 1882, or the Telegraph Acts, 1863 to 1878, and all provisions contained in this License in favour of the Postmaster-General shall be construed to be in addition to and not in modification of the provisions of those Acts.

40. Nothing in this License shall exonerate the Undertakers from any indictment, action, or other proceeding for nuisance in the event of any nuisance being caused by them.

41. Nothing in this License shall exempt the Undertakers or their undertaking from the provisions of any general Act relating to the supply of or price to be charged for electricity which may be hereafter passed.

SCHEDULE A.

The term "unit" as used in this schedule shall be deemed to mean the quantity of energy contained in a current of 1,000 amperes flowing under an electromotive force of one volt during one hour.

SECTION 1.

Where the Undertakers charge any consumer by the quantity of energy contained in the supply given to him, they shall be entitled to charge him at the following rates per quarter:—For any quantity up to 100 units, three pounds ten shillings; for each unit over 100 units, sevenpence per unit.

SECTION 2.

Where the Undertakers charge any consumer by the actual quantity of electricity supplied to him, they shall be entitled to charge him according to the rates set forth in section 1 of this schedule, the quantity of energy contained in the supply given to him being taken to be the product of the actual quantity of electricity supplied to him and the standard pressure at the point of junction of the mains and the service lines by which he is supplied.

SECTION 3.

Where the Undertakers charge any consumer by the number of hours during which he actually uses his supply, they shall be entitled to charge him at the rate specified in section 2 of this schedule, the quantity of electricity supplied to him being calculated on the supposition that the consumer uses the maximum current specified by him under the provisions of this License during all the hours that he has used the supply.

SCHEDULE B.

Railway and tramways which may be broken up by the Undertakers in pursuance of the special powers granted by this License:—

The Furness Railway.
Tramways belonging to—
The Barrow Hematite Steel Company (Limited);
The Ulverston Mining Company (Limited);
The Askam and Mouzell Iron Company (Limited);
Messrs. Harrison, Ainslie, and Co.;
The Elliscales Mining Company (Limited);
Messrs. Kennedy Brothers;
The Trustees of Myles Kennedy;
The Sandscale Mining Company.

COMPANIES' MEETINGS.

The Swan Electric Light Company.

An ordinary general meeting of the shareholders was held at the City Terminus Hotel, Cannon-street, on Wednesday last, Mr. J. S. Forbes presiding.

The SECRETARY having read the notice convening the meeting,

The CHAIRMAN said he was sorry to have called the shareholders together to attend a *pro formâ* meeting; but under the Articles of Association a meeting must be held once a year, and therefore they could not help themselves. He was not in a position, however, to lay before them any report, or to tell them very much except this, that the Directors would feel themselves in February prepared to present a report and statement of accounts, and to deal with the condition of the Company when they knew it. The fact was, as the notice indicated, very important negotiations were now pending in Germany, where, he was sorry to say, they were engaged in litigation; and he thought he could only indicate generally this—that it was very much in the interest of those negotiations, and of this Company, that they should adjourn the meeting until February. He had, in company with Major Flood Page, spent recently some time in Germany, trying to do there what they had done, he thought, with satisfactory results in England—namely, seeing if they could not reconcile divergent interests, and, instead of the Edison Company and the Swan Company abroad cutting each other's throats, to ascertain whether they could not, upon some terms or other, have a treaty of peace, or an actual fusion of interests. His own impression was, without predicting too much, or without being too sanguine, that now the common sense, so to speak, of the parties was fastened upon the results of litigation, possibly some advantageous arrangement to both sides might come out of the pending negotiations. Meanwhile they must not be alarmed if they heard that certain formal law proceedings were going on in Germany. There was one satisfaction in German law—it was equally slow with law in England, but very much less costly. He would feel rather uncomfortable if they had the same number of suits pending in any law court in England as they had in Germany. But he was not at all concerned, because he did not think they would really come to anything. On the contrary, he believed the Directors would succeed in putting an end to litigation of every kind by an agreement which would be beneficial, not only to the Swan but to the Edison Company as well. He hoped the shareholders would repose sufficient confidence in the Directors to leave them to carry out those negotiations. He did not think it would be advantageous to the Company to enter into much detail at present, and he would, therefore, move the adjournment of the meeting until the 23rd of February.

Mr. CUTHBERT QUILTER, M.P., seconded the motion, which was carried unanimously.

Mr. VERITY thought there was no occasion to send out any proxies, believing, as he did, that the Board possessed the confidence of all the shareholders.

The CHAIRMAN said it was very kind of the hon. proprietor to say so, but the experience of the Directors was not of a character to justify their going forward unprepared with any policy. Besides, there was some moral support to the Board in feeling that they had the tangible support of the large body of proprietors who did not think it worth while to come to their meetings. They liked to feel the support involved in large proprietors, who never took the trouble to come near them, sending in their proxies. The expense in connection with the subject was very small, and under the present circumstances he thought the practice was a safeguard which it might be a little dangerous to relax.

The proceedings then terminated.

Business Notice.—Messrs. Laing, Wharton and Down, electrical engineers and contractors, 8 and 9, Holborn-viaduct, E.C., have taken into partnership Mr. Arthur F. Davies, late of Lambton and Co., bankers, Newcastle-on-Tyne, who will more especially take charge of the commercial and financial departments, in the place of the late Mr. Laing, who died about a year ago.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Dec. 16.		Business Done Week Ending Dec. 16. Highest.	Lowest.
Anglo-American	31½,	32½	32	31½
Do. Preferred	53½,	54½	54	53¾
Do. Deferred	10,	11	11	10½
Brazilian Submarine	10¾,	11	10 15-16	10¾
Cuba	11,	11½	11⅝	11½
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	11¾	11½
Direct United States Cable	9½,	9½	9¾	9½
Eastern Telegraph	11⅜,	11⅞	11⅞	11¾
Do. 6 per Cent. Preference	13½,	14	13¾	13½
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12¾,	13	13	12 13-16
German Union	9½,	10	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 1-16	—
Do. Preference	13⅜,	13⅝	13⅝	13⅜
Great Northern	14,	14½	14½	13¾
Indo-European	32,	33	32½	32½
Reuter's	7,	7½	—	—
Submarine	200,	218	210	—
West India and Panama	¾,	1	11-16	—
Do. 1st Preference	8,	8½	8½	8½
Western Brazilian	6½,	6½	6 7-16	5½
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅞,	1	15-16	—
Oriental	3-16,	5-16	—	—
United Telephone	12½,	12½	12¾	12½

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3½,	4	3¾	3⅝
Do (fully paid)	5½,	5¾	5⅝	—
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1,	1¼	1 3-16	1
Maxim-Weston	5-16,	7-16	⅜	5-16

MISCELLANEOUS.

Telegraph Construction	36,	37	37⅛	36½
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24 13-16	24½

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NOTES.

BRITISH GUIANA.—The cable between Trinidad and Demerara is interrupted.

A NEW CABLE.—The cable connecting Nantucket with Martha's Vineyard, U.S.A., has been successfully landed.

OBITUARY.—The death is announced of Mr. Alfred Tribe, the well known chemist, on the 26th ultimo, at the age of forty-six years.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 18th inst. amounted to £3,395.

EASTERN TELEGRAPH COMPANY.—This company notify the opening for traffic of two new stations in China, viz., Kaiping and Shaoking, the rate being 10s. per word.

UNDERGROUND WIRES.—The Dorsett Underground Service Company has been incorporated, the object being to lay electric conduits in Milwaukee. The capital stock is £100,000.

THE TELEPHONE LITIGATION IN AMERICA.—It is officially stated that the legal expenses of sustaining the Bell patent have already amounted to considerably more than £100,000.

NOT READY.—The Society "Stædtischen Elektricitætswerke" of Berlin will not be able to commence operations before the beginning of the new year, as their machines are as yet unfinished.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th December are £2,438, as compared with £2,260 in the corresponding period of 1884.

THE PHOTOPHORE.—At a recent meeting of the Royal Microscopical Society, Mr. J. Mayall, jun., exhibited the Helot-Trouvé electric photophore, which had been recommended as an excellent illuminant for microscopical purposes.

THE LATE METEORIC SHOWER.—The correspondent of a contemporary, writing from Switzerland, reports that during the recent meteoric shower he set up a coulomb torsion electrometer and found the air highly charged with electricity.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The coupons due on the 31st inst. on the debentures of this Company, will be paid by Messrs. Barclay, Bevan and Co. The coupons must be sent in three clear days for examination.

THE TELEPHONE COMPANY OF AUSTRIA.—This company notify that coupon No. 2 on their Five per cent. Debenture Bonds, due January 1st, will be paid (less income-tax) on and after that date by Messrs. Martin and Co., Lombard-street, E.C.

THE EAST ANGLIAN EARTHQUAKE.—A report of this earthquake, which occurred, it will be remembered, on the 22nd of April last year, is about to be published by Messrs. Macmillan and Co. It has been drawn up by Prof. Meldola and Mr. W. White.

BURMAH.—A telegram from Mandalay, dated December 17th, reports that two squadrons of Madras Cavalry have arrived there, and that one troop left on that day in order to make arrangements with the Woons for keeping the telegraph wire intact.

MATHEMATICAL SOCIETY.—At a meeting of this society held on the 10th inst. Mr. A. B. Basset read a communication entitled, a "note on the induction of electric currents in an infinite plane current sheet which is rotating in a field of magnetic force."

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 18th December were £2,619, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

AT A BAZAAR.—At a fancy bazaar held at Brentford in aid of the Building Fund of the British Schools, one of the rooms was illuminated by incandescent lamps, the power being obtained from E.P.S. accumulators. The work was carried out by Messrs. Nalder Bros.

THE DIELECTRIC STRENGTH OF GASES.—At a recent meeting of the Philosophical Society of Cambridge, Dr. C. Olearski described a series of experiments from which it followed that the dielectric strength of a mechanical mixture of two gases is intermediate between the strengths of its constituents.

THE ELECTRICAL CONDITION OF THE HUMAN BODY.—An article upon the human body considered as an inductive element in electrical testing appears in the current issue of the *Electrical Engineer*. The point raised is a novel one, and we would draw the attention of our readers to the article in question.

RIVER ILLUMINATION IN CHICAGO, U.S.A.—Advices from Chicago report that it is proposed to light up the river banks by electric lights, and then urge an ordinance restricting all outgoing vessels from passing through the river during daylight. Vessels arriving will of course be permitted to make harbour.

BICHROMATE CELLS.—We advise our young readers who may amuse themselves with experimental lighting by bichromate of potash cells to prepare the solution by crushing the bichromate and dissolving in cold water. To get the maximum of effect the sulphuric acid should be added *drop by drop*. The slower the better.

GOOD!—During a sermon which he delivered recently at the Presbyterian Church, Islington, Dr. Thain Davidson said, "I am told that the submarine telegraph cable in Bass's Straits, weighing ten tons a mile, was actually floated to the surface by sea-weed which attached itself to it." We should like to see a specimen of that sea-weed.

THE ELECTRIC LIGHT AND FISHING BOATS.—A fishing steamer at Portland (Me.) has been fitted with electric light for night fishing. If the experiment proves successful, the steam whalers stationed at Province-town will probably be fitted with the lights for night cruising. The light is placed on the bows, near the pilot house, and is run by the steam hoister.

THE S.S. "MIRROR."—On Monday the s.s. "Mirror," the new cable ship built by Messrs. Napier and Sons, of Govan, for the Eastern Telegraph Company, was successfully launched from their yard on the Clyde, the ceremony of christening the vessel being performed by Lady Thomson. Amongst those present were Sir James Anderson, and Sir Wm. Thomson.

THE S.S. "GREAT NORTHERN."—The s.s. "Great Northern," the cable steamer belonging to the Eastern and South African Telegraph Company, having undergone a thorough overhauling, has been recommissioned for the East Coast of Africa, to relieve the s.s. "Chiltern." The command will be taken by Captain Smith, Mr. W. H. Cottrell resuming charge of the electrical department.

ELECTRIC LIGHTING OF OLD LEADENHALL MARKET.—The extensive premises of Messrs. G. F. Brooke and Company, of Old Leadenhall Market, have been lighted by six arc lamps and a number of incandescents, the dynamo being driven by the 12 horse-power Crossley gas engine used by the firm for

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their refrigerating process. The work has been carried out by Messrs. Craven and Elworthy.

CONTRACT OPEN.—The guardians of St. Saviour's Union, Surrey, are about to consider the subject of lighting their new infirmary at East Dulwich Grove, S.E., and are prepared to receive tenders, &c., for lighting such buildings by electricity. The tenders should be forwarded to Mr. H. C. Jones, clerk, at his offices, John-street West, Blackfriars-road, S.E., by the 13th January. Plans of the building may be seen at the offices of Messrs. Jarvis and Son, 29, Trinity-square, Borough, London, S.E.

CHROMIC ACID CELLS.—The usual printed instructions for the preparation of the chromic acid solution for batteries direct that the sulphuric acid be poured into *hot* solution of potassium dichromate; unless this be carefully done, small portions of the oil of vitrol may be projected into the face of the operator. Bunsen's method is preferable; mix the dichromate, in granular form, with the sulphuric acid, then add *cold* water, with continued stirring; the union of the acid and water generates sufficient heat to speedily effect the solution of the salt.

CHEAPER THAN GAS.—Denver, Colorado, is to be illuminated by electricity at a cost of 28 dollars per lamp, against 35 dollars, the lowest offer of the gas company. There are 450 lamps. The system is the Edison, the cost of the plant 20,000 dollars. The contractors are the Colorado Electric Company. The Denver municipal electric lighting system will comprehend twenty circuits, with twenty-seven lamps to a circuit when each circuit has its full complement. The lamp will be placed on the present gaslight posts extended up some four feet, whence the light will be thrown a greater distance than if nearer the ground.

CITY AND GUILDS OF LONDON INSTITUTE.—At a meeting of the executive committee held on Monday, it was announced that, subject to confirmation, the Mercers' Company had resolved to increase their subscription to the Institute from £2,000 a year to £3,000 a year, that the Clothworkers' Company had conditionally increased their subscription from £3,000 a year to £4,000 a year, and that the Skinners' Company had increased their subscription from £525 a year to £1,500 a year. It was also announced that the Cutlers' Company would in future contribute £105 annually to the funds of the Institute.

A NEW PERIODICAL.—We have received the first issue of a new periodical entitled, "Future Careers for our Sons and Daughters, at Home and Abroad." The contents embrace the Musical Profession; the Stage; Civil and Mechanical Engineering; the Clerical Profession; Employment of Women; the Nautical, Legal, and Scholastic Professions, and a variety of other subjects. We cut the following from the section of the paper devoted to Civil and Mechanical Engineering:—"As electricity will probably assume much greater prominence in the next generation, its application to telegraphs, railway signalling and lighting will be considered."

THE PROPOSED BERMUDA CABLE.—A contemporary says that a telegraph cable to Bermuda had long been wanted, and the Government have now recognised this by asking for tenders for laying and working one from Halifax through the island to Jamaica. The question of the defence of these cables in war time is, however, one which has not yet received the attention it deserves. One of the conditions of receiving the subsidy offered is that the Government may, in case of war, occupy any of the stations, and work the cable with its own servants. They may thus take care of the ends, but will hardly prevent it being severed in the middle.

EARTHQUAKES.—Besides the shocks of earthquake which occurred recently in the M'Sila district, disturbances have been felt at Bordj-ben-Areridj and Setif, also in Algeria. A road which was constructed not long ago from Setif to Bordj had been blocked by debris from the surrounding mountains; a bridge has also been destroyed, and a railway station demolished. It is also reported from Smyrna, in Asia Minor, that a series of seismic tremblings, commencing on the 13th ultimo had, up to the 25th ultimo, been felt at Denizulu in the interior, about 200 miles to the eastward. The shocks were very slight but were accompanied with loud subterranean noises.

BATTERY SOLUTIONS.—According to an official circular recently issued, the following are the quantities of materials to be used in charging the following descriptions of batteries used in Government departments:—Bichromates: 4ozs. of bichromate of potass and 4ozs. of sulphuric acid in the outer cell, and in the porous pot 2ozs. of mercury with a small quantity of sulphuric acid, varying according to the porosity of the cell, but in no case to exceed ½oz. Large Daniells: 5ozs. of sulphate of copper. Small Daniells: 2½ozs. of sulphate of copper Large Chambers: 3ozs. of sulphate of copper. Agglomerate and No. 1 p.p. Leclanché: 4ozs. of sal ammoniac. No. 3 p.p. Leclanché: 2ozs. of sal ammoniac.

OPENING OF A NEW CENTRAL LIGHTING STATION.—We are informed that the Brighton Electric Light Company have purchased the Brighton electric light business and plant connected therewith lately the property of the Hammond Electric Light and Power Supply Company, and have established a new central electric lighting station in the town mentioned. It may not be generally known that electricity has been for the past four years supplied in Brighton from a central station on precisely the same basis as gas—*i.e.*, the consumer has entire control over the lights he uses, being able to turn the lamps on and off just as desired, and only pays for the actual quantity of electricity used, this being determined by a reliable meter.

ELECTRIC STEERING APPARATUS.—An electrical steering apparatus, the invention of Mr. Washburn, was tested recently on the U.S.S. "Tallapoosa," in New York harbour. The invention is an electro-pneumatic steering apparatus by which a ship steers her own course automatically. The tiller is worked by compressed air, governed by electricity. The automatic principle is obtained by the introduction of an electrical mechanism into the binnacle, which, being attached to the compass at the point to which it is desired to shape the vessel's course, will hold the ship to that point, the motion of the vessel opening and shutting the circuits of the mechanism, which acts upon the rudder and corrects any deviation from the marked course.

THE TELEPHONE AT BOURNEMOUTH.—At the last meeting of the Bournemouth Improvement Commissioners, the Roads Committee reported that the manager and engineer of the Western Counties and South Wales Telephone Company attended before them and explained the system they propose for a Telephone Exchange in Bournemouth, and after hearing the explanation the committee saw no objection to the system proposed. Some discussion took place as to the question of overground or underground wires and other details, the general opinion appearing to be that as the exchange would be of benefit to the town it would be unwise on the part of the commissioners to impose restrictions which would have the effect of putting an end to the scheme. Ultimately the report was adopted.

CABLES IN ITALY.—The week before last a Bill for the putting down and maintenance of twelve submarine telegraph

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cables was brought before the House. Annexed to the Bill are two agreements concluded with Messrs. Pirelli and Co., of Milan. The first contract relates to the putting down and maintenance of these cables in working order for twenty years, which the above-named firm have undertaken to do against an annual payment of 222,144 lire. Naples is to be put in direct communication with Palermo, the cable touching at the Island of Ustica on its way, and the Eolian and Lipari Islands are all to be united with a network of cables and be put in communication with the mainland. The second contract refers to the cable ship, which is to be constructed at Messrs. Pirelli's expense, but kept in repair by the Italian Government, whose property it will become on the expiration of the above mentioned term of twenty years. Its minimum dimensions are to be, length 197ft., breadth 25ft., depth 16ft.

Engineer Volunteer Companies.—The following are the new regulations made by the War Office for the formation of Engineer Volunteer Companies for railway work :—The establishment of each company is the same as laid down for ordinary Engineer Volunteers, but the detail of trades should be as a general rule as follows : Station staff—Ticket collectors or foreman porters to act as station masters (sergeants), 4 ; telegraph clerks, 4 ; porters or pointsmen, 4. Terminal staff—Traffic inspector (sergeant), 1 ; store keepers, 2 ; inspector of rolling stock (sergeant), 1 ; engine cleaners, 4 ; engine fitters (including sergeants), 4 ; shunters, 2 ; greasers (one to be a tailor and one a shoemaker), 2 ; goods porters, 4 ; clerks, 2. Train staff—Engine drivers, 9 ; firemen, 9 ; brakesmen, 9 ; maintenance gaugers (including sergeants), 3 ; platelayers, 16 ; blacksmiths and strikers, 4 ; rivetter, 1 ; boiler maker, 1 ; sawyer, 1 ; joiner, 1 ; carpenters, 2 ; bricklayer, 1 ; masons, 2 ; tin smith, 1 ; surveyor (sergeant), 1 ; draughtsman, 1.

The Channel Squadron.—According to advices received on Friday from Arosa Bay, the Channel Squadron has arrived there after having experienced a terrific gale while crossing the Bay of Biscay. The two divisions of the squadron—one from Portsmouth and the other from Plymouth—met off the Eddystone on the 9th inst., and proceeded on their winter cruise, their intention being to go first to Lisbon. On the 12th, after entering the Bay of Biscay, both wind and sea began to increase, and by the time the middle of the bay was reached a tremendous sea was running, and all the vessels shipped heavy seas, notably the two flagships "Minotaur" and "Agincourt." The "Agincourt" had both her lower booms washed away. Her electric lights were also carried completely overboard and lost. Her nettings fore and aft, as well as the aft bridges, were smashed, and the navigation bridge was seriously damaged by the seas that broke over the ship. The "Sultan" suffered principally in her rigging and sails, and the "Iron Duke" and "Monarch" were a good deal knocked about, but not to the same extent as the other ships.

Navigable Balloons.—At a recent meeting of the United States Military Service Institution, General Russell Thayer, of Philadelphia, presented in detail his system of independent and dependent balloons, intended particularly for use in war time. In the independent balloon the motor is a high pressure air compressor, coupled directly to a newly devised carbonic acid gas engine and a reservoir for storing the air until sufficient pressure is obtained. The construction of the dependent balloon is similar to that of the independent ship, except as regards the motive power, which is here electricity. The track consists of two parallel wires supported on poles above the ground. The lower deck would be provided with two large wheels constructed to run on the under side of the wires, and two small wheels to run on the upper side. This arrangement anchors the balloon to the earth, and furnishes the motive current from a dynamo at the end of the line. It is expected that a speed of at least 20 miles an hour can be obtained. A model of the balloon and track was shown, and was operated successfully.

Oh my!—Ohm! Ohm!! sweet Ohm!!!
Watt heart re-*volts* from thee ?
The constant current of our souls
Flows on from unity.
Our every test
Has proved *thou* best,
Tho' damping aliens would invest
Thy name with lesser interest ;
That is, as we do know thee.
Tho' C's may lie 'twixt thou and E
Who Faraday may roam,
E can but take himself to C
By passing thro' his ohm.
Consoling thought—e-static dream,
Tho' quantities diminish,
And mortal coils must be unwound,
Our life's helixir passes round
Uunaltered at the finish.
(At least we hope so !)

The Telephone and the Bath Corporation.—At the last meeting of the Bath Town Council the Surveying Committee reported with respect to the application to establish a telephone exchange, and recommended that the permission required should be granted, subject to the details of the work being carried out to the satisfaction of the committee. Mr. Heywood hoped that in considering the application from the telephone company they would remember that what it proposed to do was a real public improvement. Mr. Rubie pointed out that Bath was not so much a commercial town as a resort for visitors, and he was, therefore, opposed to the disfiguration of the city by these telephone wires. Mr. Sturges contended that the telephone was a thing that should be welcomed and not shelved. The company had come before them very liberally and very considerately, and deserved their very best attention. Mr. Walker asked whether it was wise for the convenience of, say, ten or twenty persons to establish a network of wires over the streets. The Mayor said in these days he thought they could not neglect the telephone. The report was adopted.

Producing Cane Sugar from Starch by Electricity.—This method, due to L. Aubert and V. Giraud, of Lyons, depends upon the formation of saccharose from starch and water by a practical method which is substantially as follows :—100 kilograms of potatoes are heated to 100° C. in 5 cubic metres of water, with 5 kilograms of sulphuric acid, and a trace of nitric acid, until the starch is dissolved. An electric current of 11 amperes is then passed through the solution between electrodes of antimonial lead, the direction of the current being changed at intervals. In about two hours' time the solution is tested with tincture of iodine and alcohol, and if no coloration or precipitate is produced the current is interrupted, and carbonate of lime and hydrate of lime, the latter in considerable excess, are added to remove dextrine and unchanged glucose. Previously to filtration and saturation of the lime with carbonic acid, some basic acetate of lead is added to remove the colouring matter, which otherwise would interfere with the crystallisation. After concentration of the liquid in the usual way, the syrup is allowed to crystalise, which however takes somewhat longer than ordinary sugar-syrup.—Abst. *Proc.* Inst. C.E.

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TELEPHONE RATES IN AMERICA.—The revised yearly telephone rates in different parts of the United States are given as follows:—

	Subscribers.	Cities.	
Albany.........	—	....	£12 0 0
Baltimore ...	£20 0 0	Ordinary...............	13 9 0
		Fire Department ...	6 0 0
		Water " ...	20 0 0
Boston.........	24 0 0	....	25 0 0
Brooklyn......	20 0 0	Ordinary...............	18 0 0
		Leased instrument ...	4 0 0
Cincinnati ...	20 0 0	....	2 0 0
Chicago	25 0 0	....	4 0 0
Cleveland ...	14 8 0	....	—
Detroit.........	—	One-half usual rates...	
Lawrence......	15 0 0	....	7 4 0
Lowell.........	15 0 0	One-half usual rates...	
New York ...	30 0 0	....	25 0 0
New Haven...	12 0 0	....	—
Portland	15 0 0	One-half usual rates...	
Providence ...	12 0 0	One-half usual rates...	
St. Louis	20 0 0	....	20 0 0
Worcester ...	15 0 0	Instruments at special rates; connect free.	

BRIGHTON.—Mr. Magnus Volk, electrical engineer to the Corporation of Brighton, and proprietor of the electric railway now permanently established on the eastern part of the beach, has lately fitted up in his waiting rooms at the eastern or Paston-place end of the line, a very interesting novelty in the shape of a giant microscope, for public exhibition each day at a small charge. The apparatus consists of an ordinary magic lantern, with a microscope attachment in front; with this difference, that the light, instead of being supplied by a lamp or oxy-hydrogen process, is obtained by the introduction into the lantern of a powerful electric arc light with an actual power of about 700 candles. By this means, objects fixed on microscope slides may be thrown upon a white sheet, and magnified to the extent of some fifteen hundred diameters. The enlargement which is effected in a 6ft. disc may be understood when it is stated that a small pin appears 2ft. thick on the disc, with a correspondingly big head; while such interesting objects as a bee's sting, a fly's eye, a spider, the down from a moth's wing, &c., are equally well displayed. Mr. Volk proposes to give short exhibitions each time the electric car arrives from the Aquarium; and it is to be hoped that his latest venture, which is already open to public inspection, will meet with success.

RECKENZAUN'S TRAMCARS IN BERLIN.—We have received a number of Berlin newspapers giving accounts of the trial trips made with Reckenzaun's tramcar, built for Mr. G. A. Plewe, of Berlin. As we mentioned last week, success is assured for this enterprise, and the following, taken from the *Berliner Boersen Courier*, shows conclusively in what light the Germans look upon the future of electrical propulsion of tramcars:—"Many trial runs have taken place of the electric tramcar (Reckenzaun's Patent), built for Mr. G. A. Plewe, Berlin. Another trip has taken place to-day from the Exhibition to the Lehrter Station. The experiences gained are extremely favourable to the new system, and influential circles are in hopes that this electric system will be introduced on most of the routes of the Great Berlin Tramway Company. As a consequence of this, a large business has been done on to-day's exchange in the shares of the Great Berlin Tramway Company which have risen in value more than one per cent." We are informed that the authorities and the police are well satisfied with the exhibition, and have given their consent for the use of electric tramways in the Berlin streets. Great interest seems to be taken in these electric trips on the part of the general public at Berlin, and among the gentlemen mentioned as having taken part we note the Right Honourable Lord Thurlow, Baron Richthofen, Captain Albert, Vogel, &c.

ANOTHER WONDER.—A German explorer, one Dr. Kümmel, has discovered, it appears, an electric tree, the *Elsassia Electrica*, in New Guinea. He proposes to chop it into slices and set up a central station for lighting by solid generators. The following description is given of the find:—"I stopped under a large tree which seemed particularly to attract the attention of Kümmel, who had been finding all kinds of novelties the whole morning, to take the exact bearings of a high peak, which was visible through an opening in front of us. To my surprise, the compass seemed utterly drunk. Whilst Kümmel and I were discussing this phenomenon one of the men struck with a *machete* one of a number of peculiar buttresses, which ran up the outside of the tree, splitting off a large slice and severing a curious looking black core, which formed the centre. Kümmel placed his hands on the two ends of the core to look at it more closely (rational action), and instantly gave a yell and rolled head over heels, getting up without his spectacles, and stammering that he had had a severe electric shock (say, 150 volts!!!)." The expedition did not possess a galvanometer, but an apology for one was made with a helix of copper wire and the compass, the result going to show that a strong current was passing through every portion of the tree. A forest of these trees was seen; the locality being nearly bare of other vegetation. The black core, we are informed, is composed of pure amorphous carbon! Here is a chance for another boom!

STEALING ELECTRICITY.—A contemporary gives an account of a new industry that has seemingly sprung up amongst the light-fingered gentry of America. It appears that the leakage to the earth of the underground leads of the Edison electric lighting system from the central lighting station in New York, U.S., is to be about three amperes, the tension being 110 volts. It was found that numerous unprincipled persons had availed themselves of the opportunity to steal electricity—an offence surely unknown to statute law—and use it for operating motors, and for induction coils. The method of filching the electricity was by boring through the iron pipe surrounding the insulating compound, and then further into one of the copper leads; a set screw fixed into this orifice, formed one connection, and the earth the other. Of course this connection was made beyond the electric meter. It was hardly worth while to maintain the continuous *espionage* necessary to detect and punish these pilferers, but the superintendent of the station, Mr. Chamberlain, coupled in extra dynamos and threw as great an increase of current over the system as the safety catches would permit, at various times. For about one second while this current was passing the incandescent lamps would give an unwonted glow, and every induction coil and motor surreptitiously attached to the system would receive an extra current designed to burn it. In this manner the system is occasionally cleared of all trespassers.

THE TELEPHONE AT WINDSOR.—At the last monthly meeting of the Windsor Urban Sanitary Authority Mr. Simpson attended, and asked for their co-operation in laying a telephone under the following circumstances:—He said he wished to have a telephone to connect his house with his farm, and he had applied to the Post Office to know the cost, and they gave him the cost of laying and maintaining at £33. 5s. a year. That seemed to him a large sum of money, inasmuch as the Post Office had a telegraph wire laid the whole distance. He had since been in communication with the South of England Telephone Company, and they offered to do it for £18, either

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party to terminate the agreement by three months' notice. He then ascertained from the company that they would place the wire to Datchet and Old Windsor for £40, divided between four. The company reckoned upon going by the South Western Railway, but if the Sanitary Authority or the Board of Guardians came in it would be made advantageous for them if the line went the other way. At any rate the company's representatives were looking over the ground then, and the chairman said the cost would be £60, then £50, and he (Mr. Simpson) dare say that meant less. The authority would remember that telegraph communication with Ham was one of the things recommend by Mr. Hawksley. If they would pass a resolution authorising the Mayor to incur an outlay not exceeding £10 per annum, there might be a probability of getting the matter in hand at once.—The Surveyor said it would be a very good thing; but if they decided to have a telephone it would be better to put one up themselves, and not rent one from a company.—The matter was then referred to the Health and Drainage Committee.

Technical Education in New South Wales.—A technical college has been established in Sydney under the direction of the Board of Technical Education. The course of studies for the students, and system of instruction adopted, is practically similar with that employed by the City and Guilds of London Institute. The college contains thirteen departments, viz. :—Agriculture, including agriculture, botany, and veterinary science. Applied mechanics, including mechanical drawing, naval architecture, and metal-plate working. Art, including practical plane geometry, practical solid geometry, perspective model drawing, freehand drawing, &c. Architecture, including carpentry and joinery, masonry, bricklaying, carriage-building, plumbing, and cabinetmaking. Geology, including mineralogy and mining. Chemistry, including laboratory instruction in practical and theoretical chemistry and metallurgy Commercial economy, including French, German, Latin, arithmetic, book keeping, caligraphy, and correspondence. Mathematics, including civil engineering, surveying, navigation, and actuarial science. Music, including class singing and instruction in theory, harmony, composition, &c. Elocution, including art of public speaking and reciting. Pharmacy, including *materia medica* and pharmacy. Physics, including natural philosophy, optics, sound, electricity, and telegraphy. Domestic economy, including cookery and household management. The number of students in the college classes amounted last year to 2,128, and at the annual examinations of the Board 590 attended for examination, and 350 passed. The instruction given is of a very high order, and has been productive of excellent results. The fees are exceedingly low, so as to give every opportunity to young men of obtaining a thorough technical education.

The Inter-Continental Telephone Company.—This company is organised under the laws of the State of New Jersey, and has acquired all the telephonic rights, franchises, and property formerly owned by the Tropical American Telephone Company, in Venezuela, United States of Colombia, Panama and Central America. The company has secured a concession from the Government of Venezuela, giving it the exclusive right to establish and maintain telephonic lines and exchanges in and between the cities of Venezuela, and has already in full operation an exchange in the chief city, Caracas, with 475 paying subscribers. At La Guarya, the chief port of entry to the country, there is also an exchange, with about 100 subscribers, and the two cities above-named are connected by a trunk line with four wires, giving the subscribers of both places instant telephonic connection with each other. There is also a similar system at Valencia and Porto Cabello, cities of next importance in Venezuela, with trunk line between them, and 150 subscribers are already secured at Valencia and 125 at Porto Cabello. It is proposed to establish similar systems at Maracaibo, Barquisimeto, Bolivar, Barcelona, and the other cities of Venezuela wherever 50 or more subscribers can be secured. In United States of Columbia a sub contract has been made with The Columbia and Panama Telephone and Telegraph Company, which latter, organised under the laws of the State of New York, with a capital of 100,000 dollars, is doing the telephone business in Columbia and Panama. Exchanges have been established at Bogota, Barranquilla and Carthagena, and others will be commenced wherever a sufficient number of subscribers can be secured to support a central office. In Central America a contract has been entered into with Messrs. Wendell and Phillips, of Boston, giving to them for a term of years the exclusive right to export from the United States and sell, lease, and use in that territory Bell and Blake telephones and transmitters. At Guatemala city an exchange has already been established with 200 promised subscribers, and opportunity is offered for the establishment of central office systems at other cities in Central America.

The Tropical American Telephone Company.—This company, organised in November, 1881, acquired from the Continental Telephone Company of Boston (the assignees of Prof. Alexander Graham Bell, Francis Blake, Watson, Anders, Roosevelt, Fuller, *et al.*) all telephonic rights formerly its property in Central America, United States of Columbia, Venezuela, British, Dutch, and French Guiana, Chili, Peru, Ecuador and Bolivia, South America, and all the West India Islands, except Cuba (already ceded to the Cuban Company). By subsequent purchase it obtained from the Continental Telephone Company all its existing telephonic rights in Brazil and the remaining countries of South America, including valuable contracts with subsidiary companies; and now has the sole and exclusive right to sell, lease, and use "Bell" telephones, "Blake" transmitters, and all other telephonic apparatus manufactured by the American Bell Telephone Company, under patents owned or controlled by it in the United States and Canada, in the entire territory of South America, Central America, and West Indies, named below, and is the source of supply for telephones, transmitters, telephonic instruments, and supplies to the following telephone companies, already organised and doing business, viz. : — The Inter-Continental Telephone Company, controlling Central America, United States of Columbia and Venezuela; the West India Telegraph and Telephone Company, controlling Jamaica, Porto Rico, Hayti, San Domingo, &c.; the Columbia and Panama Telegraph and Telephone Company, controlling United States of Columbia and Panama; Companhia Uniao Telephonica do Brazil, successor to the Companhia Nacional de Electricidade and Companhia de Telegraphos Urbanos, operating in Bahia, Pernambuco, Para, Santos, Campinas, and elsewhere in Brazil; Companhia Telephonica do Brazil, operating in Rio de Janiero and Nictheroy, Brazil; West Coast Telephone Company, controlling Chili, Peu, Ecuador and Bolivia; the Commercial Telephone Company, Limited, controlling the Island of Trinidad, West Indies; the Barbados Telephone Company (Limited), controlling the Island of Barbadoes, West Indies. The Tropical American Telephone Company established exchanges in Barbados and Trinidad, West India Islands, and sold the business and plants to the last two companies, and will continue to supply the private line and exchange telephone business throughout the entire territory now under its control.

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THE STEAM ENGINE INDICATOR.—XIII.*

BY AMICE.

The hyperbolic curve of expansion is often called the isothermal curve of expansion, because a gas such as air gives this curve when it expands from one volume to a larger volume, providing that the thermal conditions remain the same. The pressure of such a gas varies inversely as the space it occupies only so long as the temperature remains constant. Thus a curve representing the fall of pressure of a gas as inversely proportional to its volume represents that pressure when and only when the expansion takes place in a vessel in which the air is maintained throughout the whole period of expansion at the same temperature, or when it takes place isothermally. Now, it only happens, that under ordinary conditions of working in well made steam engine cylinders, the curve of pressures of the expanding steam very nearly follows this hyperbolic curve or so-called isothermal curve. It must be remembered that, with respect to the expansion of steam, it is not an isothermal curve, inasmuch as the temperature of steam in any cylinder falls during expansion. Thus, with steam at 75lb. absolute, *i.e.*, including the pressure of the atmosphere, expanded down to a pressure of 5lb. absolute, the temperature falls from 307·5deg. to 162·4deg. The hyperbolic curve does not, therefore, represent isothermal expansion of steam, as that cannot take place; it only approximately represents the relative pressures and volumes of expanding steam.

As a means of obtaining the mean pressure throughout the stroke when a diagram cannot be taken, or for estimating the probable indicated horse-power of an engine of given dimensions, steam pressure, and cut off, a formula based on Boyle's law, and containing a hyperbolic logarithm, is used, and is as follows:—

$$p = P \times \frac{1 + H}{R};$$

p being the mean pressure;
P the initial pressure;
R the range of expansion.
H the hyperbolic logarithm of R

Thus for a pressure of 75lb. absolute cut-off at one-fourth the stroke, or in other words used with a range or ratio of expansion of 4, for which the hyperbolic logarithm is 1·386, we have $p = 75 \times \frac{2·386}{4} = 44·7$lb. per square inch as the mean pressure.

In the steam engine cylinder, if of a condensing engine, this will be lessened by the imperfect vacuum, or by the back pressure. This will vary in different engines, but is seldom less than from 3lb. to 4lb.

The mean pressure thus obtained is the same as that given by a hyberbolic curve, and it must be remembered that the steam admitted to fill the clearance and port spaces must be taken into consideration. The power of the engine during the steam admission period is not affected by this amount of steam, but the total mean pressure throughout the stroke is increased by it. Thus, in the above case, when the clearance steam is taken into account, the ratio of expansion is lessened, while the period of steam admission and the stroke remains the same, a condition not easily taken into the calculation, though very easily measured on a diagram. It is clear that the pressure is maintained at a higher pressure than it would be during expansion were it not for the steam so admitted, and we can only take it into the calculation by allowing for its volume, and assuming a smaller range of expansion. For instance, in the above case, if the clearance represented a volume equal to one-eighth the capacity of the cylinder, then, instead of the ratio of expansion being $\frac{1}{4}$, or $\frac{2}{8}$, it would be $\frac{3}{9}$, or R would be 3, but the work done would not be in proportion to this, as the full pressure steam would not have effect on the piston during more than the $\frac{1}{4}$ stroke.

The difficulty is that by adding the amount of the clearance to the steam admitted to the cylinder before cut-off we charge the piston with a greater duration of full pressure than it actually has, for the steam admitted to fill clearance spaces does no work during admission, yet we must credit it with doing work during expansion. The only possible way of calculating the mean pressure throughout the entire stroke is thus to take the whole of the steam admitted, and after obtaining the mean pressure from this, to deduct the amount of work that would be done by the steam admitted to fill clearance, if it were admitted during the movement of the piston instead of before it. Thus, taking the above case, the mean pressure, the hyperbolic logarithm 3 being 1·098, will be $75 \times \frac{1 + 1·098}{3} = 52·4$. This is the pressure during the whole length of the cylinder, including clearance as part of the cylinder, assumed as above to be nine units of length. But the piston is not able to make any use of the pressure existing the first ninth of the cylinder, this part or ninth being the clearance. This amount must then be credited to the piston. It may be thus done as a comparative example:—

Total pressure throughout cylinder and on unit area	=	$52·4 \times 9 = 471·6$
Less ineffective pressure during admission	=	$75·0 \times 1 = 75·0$
Total pressure throughout stroke		$= 396·6$
Mean pressure throughout stroke of piston	=	$\frac{396·6}{8} = 49·57$

This is not absolutely accurate, but it is sufficiently accurate for all practical purposes. It shows how very important a part clearance may play, not only in explaining the much higher pressure which is found in cylinders during expansion than would be obtained were it not for the steam used in filling clearance spaces, but it shows how large a quantity of steam may be lost by clearances when sufficient compression is not employed, or when it cannot be employed. It will also be seen that the effect of clearance is greater with high pressures and early cut off or long ranges of expansion than with low pressures and small ranges of expansion. We need not follow this with reference to adiabatic expansion, as this, though of importance in theoretical investigations, is not so in practice.

If steam is expanded in a non-conducting cylinder, and neither receives nor loses heat by conduction or radiation, it is said to be expanded adiabatically. In this case the pressure falls in proportion to the amount of work done by the piston. If the work done is 772 foot-pounds, then the thermal equivalent of this, namely, one unit of heat, is abstracted from the steam, and the pressure falls in proportion to that one unit. At least, this is assumed to be the case, and although there is no direct experimental proof that the performance of work of itself causes the abstraction of heat, it is reasonably assumed that this is the case; and as a large quantity of heat is lost, it is assumed that this is one of the sources of loss. In as much, however, as non-conducting and non-radiating cylinders do not exist, the curve which represents adiabatic expansion is not of much importance in this connection. We are not, however, clear that adiabatic compression or an approach to it does not occur when considerable compression is employed. Under adiabatic conditions the pressure, according to Rankine, varies nearly as the reciprocal of the tenth power of the ninth root of the space occupied, or P being pressure, $P \propto \frac{1}{v}^{-\frac{10}{9}}$. To find the pressures from Rankine's formula involves a good deal of calculation, but a table of constants is given by Mr. Northcott in his work on the steam engine, which facilitates the calculation, and from this we may take a few figures, obtained by the formula $\frac{p}{P} = \frac{10 - 9r^{-\frac{1}{9}}}{r}$, p being the mean pressure. (Table A.)

To find the mean pressure exerted through the stroke when expansion takes place under these conditions it is only necessary to multiply the constant opposite the ratio of expansion. Thus, dry steam at 75lb. per square inch expanded adiabatically from one volume to four volumes will give a mean pressure of $75 \times 0·571 = 42·82$lb. The loss of pressure as compared

* For Art. 12, see *The Electrician*, 18th December, 1885.

with steam expanded in a jacketed cylinder is thus 44·7 – 42·8 = 1·9lb.

TABLE A. ADIABATIC EXPANSION.—*Constants for Mean Pressure.*

Ratio of Expansion	Constant.	Ratio of Expansion.	Constant.	Ratio of Expansion.	Constant.	Ratio of Expansion.	Constant.
1·5	0·931	3·5	0·622	5·5	0·467	7·5	0·373
2·0	0·833	4·0	0·571	6·0	0·438	8·0	0·357
2·5	0·748	4·5	0·529	6·5	0·414	8·5	0·341
3·0	0·678	5·0	0·495	7·0	0·393	9·0	0·327

An adiabatic curve of expansion may be constructed by taking out any number of final or terminal pressures—that is to say, pressures at any number of given ranges of expansion, as follows. The terminal pressure with adiabatic expression will be

$$p' = \frac{P}{R^{\frac{10}{9}}}.$$

For example, we may take the following diagram, Fig. 42, which is the same as Fig. 39, page 68, but with the dotted curve added, showing the curve of expansion when adiabatically effected. In this diagram A B C D represents the unit

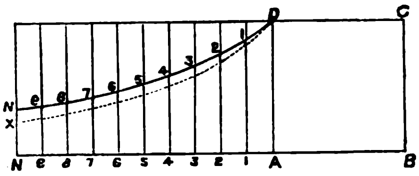


FIG. 41.

volume admitted before cut off. Estimating the pressure at the line 2-2, that is after expansion has increased the volume from 1 vol. to 1·4 vol., each of the spaces on this diagram being = 0·2, or two-tenths of the volume represented by distance A B, and taking the initial pressure as 63lbs. as before, we have $p' = \frac{P}{R^{\frac{10}{9}}} = \frac{63}{1·4^{\frac{10}{9}}} = \frac{63}{1·45} = 43·4$ lbs.

In this way we may get the pressures at any number of points.

Taking our diagram they are on the ten pressure or pressures at D, &c. :—

D,	1,	2,	3,	4,	5,	6,	7,	8,	9,	N.
63,	51·6,	43·4,	37·38,	32·8,	29·1,	26·2,	23·8,	21·8,	20·2,	18·5.

The several pressures being set off as ordinates we get the adiabatic curve D, X, which is below the hyperbolic curve D N by the amount which the steam pressure would lose if it were expanded in a perfectly non-conducting cylinder.

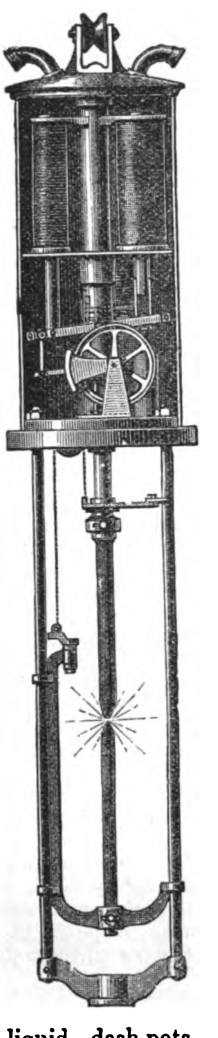
The following figures give terminal pressure ratios for a few ranges of adiabatic expansion, or $R^{\frac{10}{9}}$.

Ratio of Expansion R.	Adiabatic Ratio $R^{\frac{10}{9}}$.	Ratio of Expansion R.	Adiabatic Ratio $R^{\frac{10}{9}}$.
1·1	1·11	5·0	5·98
1·2	1·22	5·5	6·64
1·3	1·34	6·0	7·32
1·4	1·45	6·5	8·00
1·5	1·57	7·0	8·69
2·0	2·16	7·5	9·38
2·5	2·76	8·0	10·08
3·0	3·39	8·5	10·78
3·5	4·02	9·0	11·50
4·0	4·66	9·5	12·22
4·5	5·32	10·0	12·94

DYNAMO TESTS.—The results of the dynamo tests at the Philadelphia Exhibition, as published in the report issued by the Franklin Institute, will be reprinted in an early issue.

THE BROCKIE-PELL ARC LAMP.

The accompanying illustration shows the present form of this lamp, the principle of which is essentially different from others of the direct-acting class. Nearly all such lamps are regulated by the differential action of two coils, one being in the main circuit and the other in a branch or shunt across the arc. This combination necessitates the main coil being made more powerful than the shunt, and therefore any change in the main current very readily and considerably affects the regulation.



In the Brockie-Pell lamp it is claimed that the two coils are so peculiarly related to each other that the main coil may be of very much inferior strength to that of the shunt coil, and therefore much greater variations in the main current may take place without unduly lengthening or shortening the arc; thus a steady light is obtained even with a variation in the main current of 25 per cent. above or below the normal or working current. The lamp may be briefly described as "semi-differential," because the main coil plays a smaller part in the regulation than in purely differential lamps; in fact, the main coil is only made powerful enough to separate the carbons and obtain the arc, the shunt coil coming into operation afterwards and playing the leading part in the regulation.

The mechanism is simple and strong, and is calculated to withstand considerable rough usage. The adjustment is effected by means of weights, which cannot alter, and, when once adjusted to the normal working current, the lamp is said to work well without any other attention than the usual cleaning of the sliding rod, which must not be neglected in any arc lamp. There are no trains of wheels, liquid dash-pots, regulating springs, nor make-and-break contacts, and the working parts have been reduced to the lowest possible number. As a proof of the perfection in the feed of this lamp, the makers (Messrs. Johnson and Phillips) give the result of an experiment recently made—viz., a very delicate Thomson mirror galvanometer was placed in a shunt circuit across the arc whilst the lamp was burning, and the variation in the range of the spot of light on the scale did not exceed 10 divisions in 300.

OBITUARY NOTICES.

CAPTAIN SIR FREDERICK J. O. EVANS, R.N., K.C.B., F.R.S.

Captain Sir F. J. O. Evans, late hydrographer of the Admiralty, died on Sunday last at his residence, 21, Dawson-place, in his seventy-first year. The deceased officer entered the Navy in the year 1828. In 1855 he was appointed superintendent of the Compass Department of the Admiralty, at a period when the science of terrestrial magnetism in relation to iron ships was in its infancy; he was at this time a mathematician of no mean repute, and sagaciously foreseeing the important part this abstruse science was destined to play in the Navy, now being revolutionised by the change from wood to iron, he devoted his whole energies to the study of the subject until he had made himself completely master of it. In conjunction with that accomplished mathematician, the late Mr. Archibald Smith, F.R.S., he published, in 1869, the "Admiralty Manual for Ascertaining and Applying the Deviation of the Compass," which was translated by all maritime nations, and has been the accepted text-book in our own and other navies up to the present time. In 1865 Captain Evans was appointed chief assistant to the hydrographer, retaining also

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his position as head of the magnetic department. In 1874, a vacancy occurring for the post of hydrographer, he was appointed to fill it. He had enjoyed the cordial friendship, esteem, and entire onfidence of the three officers who had preceded him, and no more proper or worthy selection could have been made. He continued to perform the important duties of this office with great ability and conscientiousness until within little more than a year of his death. Sir F. Evans was elected a Fellow of the Royal Society in 1862, and served for many years on its council, and was more than once a vice-president. He was nominated a K.C.B. in 1881.

THE LATE MR. GEORGE HENDERSON.

The late Mr. George Henderson was born at Borrowstounness, County of Linlithgow, on the 4th of December, 1813, having at the time of his death just entered his seventy-third year. He was educated at the School of Dollar, in Clackmannanshire, and when a very young man moved with his father, Mr. George Henderson, a shipowner, to the port of Liverpool. The style of his father's firm, which was founded by his grandfather, was Robert Henderson and Sons, of which, with his brother, the late Mr. Robert Henderson, of Mincing-lane, he eventually became a partner. While continuing a partner of his father's firm he joined the members of a Calcutta house, who were the correspondents of his late uncle's firms, Messrs. R. and J. Henderson, of London and Glasgow, and moved his place of business from Liverpool to London. The firm in Calcutta, of which at the time of his death he was the head, is George Henderson and Co., and in London George Henderson and Sons. Mr. Henderson was mainly instrumental in developing the jute spinning industry in India, showing for the first time (which had been doubted) that the natives of Bengal were capable of being converted into useful factory operatives. With the assistance of Mr. Thomas Duff, he founded the company, for some time carried on as a private enterprise, and which was afterwards converted into the Barnagora Jute Factory Company (Limited), and in conjunction with his partner, the late Mr. Herbert Knowles, introduced into Bengal the manufacture of paper by machinery. Mr. Henderson took a warm interest in the progress and consolidation of the India Rubber, Gutta Percha, and Telegraph Works Company (Limited), of which he was for many years the honoured chairman, and he was also a director of the Borneo Company (Limited). He expired at his residence, Heverswood, parish of Brasted, Kent, on the 11th inst., having been absent from business only six weeks. His remains were interred in the family vault, in the churchyard of Sundridge, and were followed to their last resting place by a large assemblage of sorrowing friends. In public life he was much respected, and as the funeral *cortége* passed through the village every house was closed.

MAGNETISM.

BY WILLOUGHBY SMITH.

Let it be assumed as correct, it not being of the slightest importance for my present purpose whether it be so or not, that a Greek shepherd, Magnet by name, whilst tending his flock on Mount Ida, found that there were in parts of the earth around him peculiar hard substances, from which, if he placed his iron crook upon them, he had difficulty in detaching it. Neither is it, at this time, of material importance to know the date of this discovery; but it may be noted in passing that it must have been a very long time ago, as Homer, Pythagoras, Aristotle, and other celebrated men of their time mention it in their writings. It is even asserted that Thales, the most ancient philosopher of Greece, was acquainted with the attractive power for iron possessed by the substance called magnet, this name being given to it, I suppose, with the view of perpetuating the name of the discoverer of what must have seemed in those days a supernatural phenomenon.

It does not, however, appear that these ancient philosophers attempted to gain knowledge by experimental research, although they were such close observers of nature and its workings. No doubt the discovery of so strange and wonderful a phenomenon was a subject for much learned discussion and disputation in their schools of science; but they had not realised the important fact that theory and experimental research should go together, for useless is the theory that cannot be supported by experience, and experience, without some theory of generalisation and arrangement, would be nothing but a confused mixture of facts. Had this been more fully recognised it is possible that the most important property of the magnet – its directive force—would not have remained so long undiscovered. For it is recorded that it was not until the thirteenth century that it became known, at any rate in Europe, that when a magnet was freely suspended it turned one and always the same part of its surface towards the north pole of the earth, or a point not far from it; the opposite part of its surface, of course, pointing south; these parts were then termed poles.

When this directive force was practically applied to navigation and similar purposes, the magnet became more generally known as the "loadstone," a word said to be derived from a Saxon term signifying a "guide."

The magnet or loadstone is an oxide of iron of a dark grey or dark brown colour, found in almost all parts of the world, generally in irregular pieces of a few inches in dimension, although pieces have been found weighing over 100lb., and capable of supporting by suspension pieces of iron of double their own weight. It doubtless was soon observed that the directive force of these stones was very capricious, owing to the extraordinary difference in various parts of the same stone; for while one part would attract another would repel the same substance. This difficulty was surmounted by the discovory that by placing a plate of iron on each end of the stone, all the power of the stone appeared to centre itself in those iron plates and to give strong and uniform directive power. After the application of the iron plates it must soon have been observed that they, more or less, retained the property of the stone after their detachment from it, and that the harder the iron the more lasting was the effect. When the knowledge was fully recognised that the directive and attractive power of the stone could be imparted, without loss to itself, to hard iron or steel and permanently retained thereby, magnetised bars, or needles as they are now called, superseded the loadstone for ship's compasses and other like purposes, and the term magnet was again more generally applied. At the present time the word "loadstone" is very seldom if ever used, unless in application to the stone itself.

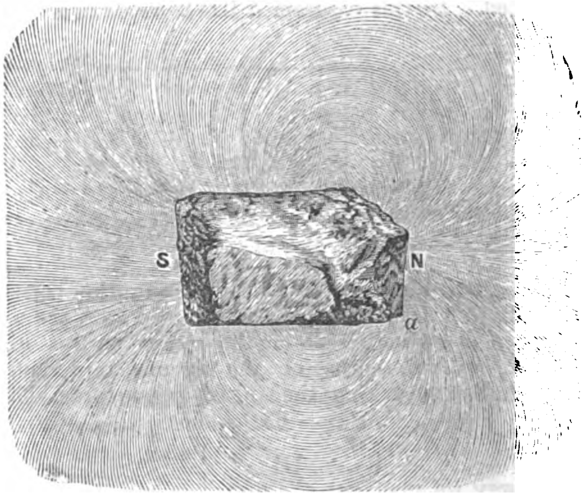

Diagram I. represents a natural magnet or loadstone which I have in my possession. It is a magnetic iron ore of a specific gravity of 4·9, and, according to Bloxam, this variety of ore contains about 72% of iron. Its weight is 17,730 grains, but its attractive power is very slight, owing to its possessing what may be termed so many points of action, as represented in the diagram. The attractive power at many of these points is scarcely perceptible; the strongest point is marked *a*, and even there it will only support 17 grains of iron. But it will sustain a plate of iron weighing 1531·25 grains, if the iron be of sufficient surface to cover the whole of the base; and if the iron be extended so as to cover the two ends also, its attractive power will be increased to 24,062·5 grains. Taking the soft iron end pieces separately, while in contact with the stone, their respective attractive power is

North..	2645 grains.
South..	2437·5 ,,

If one of the soft iron pole pieces be applied to different parts of the stone, then, as far as it is possible to ascertain, where any considerable attraction takes place between the stone and the iron, very little free magnetism is shown by the latter; but if no attraction exists between them free magnetism is manifested at the end of the iron. I cannot tell when this stone was first used for experimental purposes, but, forming my opinion from the antiquated character of the engravings on the brass case in which it is mounted, I should say it was at least three hundred years ago; and, if I correctly interpret the engraved figures, its strength has since that time decreased more than fifty per cent. Writers on the properties of this class of ore or stone have frequently expressed their astonishment at the way this power, which we call magnetism, exists naturally in them. Even Faraday has said that "The way in which it exists at all times in a stone like this is the most remarkable fact connected with magnetic force." Whenever giving thought to the subject I always imagine the earth as one huge loadstone, and consequently look upon it in the same way as upon the small stone, the properties of which I have just given; for if the world could be experimented with in

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precisely the same way, similar results would be obtained, the only difference being the high attractive and directive power of the one over the other, owing to the vast difference in their dimensions.

This would be analogous to experiments carried out with a huge magnet and a very minute portion of the same, for similar magnetic effects would be obtained in each case, but the difference of the intensity between the two would be very great. Astronomers consider the world an oblate spheroid body, elevated at the equator and depressed at the ends, and, for convenience, they imagine a line passing through its centre, and the extremities of this imaginary line they term the poles.

Now at or near the place of these imaginary poles the earth has its strongest attractive magnetic power; consequently, proceeding from these two points are strong magnetic curves lines of force, which, by their polarisation effects, cause the atmosphere surrounding the earth to be one whole magnetic field. To what height those curved lines extend it is impossible to say, for we can only positively assert that the boldest aeronaut has not yet ascended beyond their influence.

When experiments in magnetism are being made, it should be constantly borne in mind that the work is being done in an atmosphere of magnetism, the lines of force of which vary in intensity according to the position on the earth at which the experiments are made; and not only the position, but also the time and temperature.

If this be really the state of the planet on which we dwell, may it not be probable that the other planets, which are said, like this world, to be "swimming" in the medium of space around the sun, each one being surrounded by its own atmosphere, are similarly affected; and that polarised magnetic lines of force are the means employed by the great Architect of the universe (who, as far as our limited knowledge extends, employs no rectilinear motions or angles, but all motions created by Him are performed in curved lines) to bind together and control the whole system.

> "See plastic Nature working to this end
> The single atoms each to other tend.
> Attract, attracted to, the next in place
> Formed and impell'd its neighbour to embrace.
>
> * * * *
>
> All served, all serving, nothing stands alone.
> The chain holds on, and where it ends unknown."

Having discovered the attractive and directive power, and the dip of the magnet, it appears to have been assumed that the whole subject was exhausted, as very little more attention seems to have been given to it, until Dr. Gilbert, in the year 1600, published his original treatise on the magnet. This created quite a new and enthusiastic interest in the subject, especially his hypothesis of terrestrial magnetism, in which he assumed that the earth contained within itself a powerful magnet, lying in a position nearly coinciding with its axis of rotation. Some of the enthusiasts of the day accepted this hypothesis as correct, and looked upon it as one of the greatest discoveries in the annals of science, whilst others propounded new theories which as fully illustrated how erratic is the unbridled imagination, especially when it has overleaped the bounds of reason. Although the advancement of knowledge will not allow of the correctness of many things recorded by Gilbert and other writers of his time, yet it may be still admitted, with truth, that Dr. Gilbert did much to increase our knowledge, and that he is justly termed "the father of the science of magnetism." The magnetic effects which were observed to be produced by lightning—Franklin's discovery of the identity of lightning with electrical discharges artificially produced; and the effects produced on magnetic needles by the aurora borealis, combined with the facts that similarly electrified bodies repel each other in the same way as those bodies which are similarly magnetic, and that dissimilarly electrified bodies will attract each other in the same way as those bodies which are dissimilarly magnetic, encouraged philosophers in their endeavour to identify the electrical and magnetic powers as one and the same. Powerful currrents from large electrical machines, or from batteries formed of large Leyden jars, charged to their highest tension—the only known means in those days of generating and accumulating electricity—were passed through bars of steel or iron of all forms and under all conditions; but the results obtained were very slight and capricious, and showed no advantage over the magnetic effects usually produced by a blow given to a bar of iron from any mechanical action. Father Beccaria, a celebrated Italian philosopher, concludes his experiments in this direction by asking "Are not these peculiar effects of this electric *fire* with respect to magnetism so many proofs which corroborate my former conjecture, that the peculiar magnetic force observed in *loadstones* is to be attributed to either atmospherical or subterraneous strokes of lightning, and that the universal systematical properties of magnetic bodies are produced by an universal systematical circulation of the electrical element?" These remarks of Beccaria's do not appear to have attracted much attention at the time, but fifty years afterwards Ampère suggested a similar theory which attracted much attention; but then Ampère had had the advantage of two most remarkable and important discoveries which had been made since Beccaria propounded his theory.

It has often been found that experience produces facts which the wildest imagination never conceived even in its dreams. Bold, if not absurd, would have been considered the flight of imagination of the romancer who compiled his work from such incidents as those which belong to the history of Volta electricity. For instance, in 1790 an Italian lady slightly indisposed was advised by her physician to partake of some frog broth; her husband being an anatomist, at once proceeded to prepare the frogs, and while so doing observed that the disconnected limbs became convulsed with movements resembling vital action whenever they were touched at the same time with any two dissimilar metals, iron and copper for instance.

The important results which have sprung from this simple incident illustrate the beautiful and unerring laws of nature developed under the most simple conditions, but which are too often, on that account, unheedingly passed by. This strange and startling phenomenon led to experimental research; and had Prof. Galvani been more of an electrician, he probably would not have adhered so tenaciously to his theory of animal electricity. The results of Volta's experiments led him to assert that Galvani's theories were incorrect, and that the phenomenon was not due to animal electricity but simply to a current of electricity emanating from the surface of contact of two metals; but Prof. Fabroni discarded both the preceding theories, and experimentally demonstrated that electricity was generated by the decomposition of the moisture lying between the two metals.

Each of these three hypotheses had their own partisans, but the controversy as to the origin of galvanic electricity, as it was then called, somewhat abated when, in March, 1800, Volta announced his discovery of the voltaic pile, composed of a combination of alternate discs of copper, zinc, and wet cloth. By this arrangement a generator of electricity was produced which gave a gentle and continuous current in large quantity, and not the sudden or instantaneous currents with uncontrollable and irresistible violence which had hitherto been obtained. From this discovery, commenced the most splendid era in the history of electricity; it supplied experimentalists with a new implement for electrical research, amongst the foremost users of which was Sir Humphrey Davy, who, although a young man of only twenty-one years of age, not only put beyond doubt the fact that chemical action is essential to the vitality of the voltaic pile, but showed different methods of generating currents, and thus localised sufficiently for all practical purposes the "seat of electromotive force in a voltaic cell." A few years afterwards he published that most important discovery of the decomposition of fixed alkalies by currents of electricity generated by chemical action, and of the metallic nature of their bases, thus founding a new science of electro-chemistry. These discoveries burst so suddenly and unexpectedly upon the scientific world as to cause great wonder.

Electro-magnetism was again eagerly sought for, this time by the aid of the voltaic pile, and, after twenty years of labour and thought, the experiments of Prof. Oersted carried him victorious to the desired goal; for he then discovered that an electric current, traversing a metallic wire joining the two poles of a voltaic battery, will deflect an adjacent magnetic needle from its natural direction; and that, in the absence of interfering forces, the latter would be placed at right angles to the former, thus demonstrating, by actual experiment, that an electrical current communicates magnetic properties, by induction, to such bodies in the vicinity as are susceptible of acquiring them. Prof. Oersted thus proved that there exists a reciprocal action between electric currents and magnetic bodies, and this was the foundation of the whole science of electro-magnetism. The discovery of the magnetic properties of electrical currents was at first received throughout the world with unqualified astonishment, as all previous attempts to identify electricity and magnetism had been unavailing. It was soon ascertained that Prof. Oersted had opened a new field of research, and its fertility was manifested by the great variety of interesting facts speedily brought to light by the emulative labours of experimenters; in fact, so rapid was the development of discovery in this new field of Oersted's that it was very difficult, if not impossible, for those whose attention could not be exclusively devoted to the subject to keep pace with its progress.

With the knowledge of Oersted's discovery, it would naturally suggest itself to every person giving thought to the subject, that if a conductor connecting the dissimilar metals of an electrical battery possessed magnetic properties, whilst so placed, then it would be fair to suppose that all the effects which can be obtained from a magnet should be obtained from a wire so placed, and their experiments would naturally be in that direction.

(To be continued.)

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

VOLUME XV.

Volume XV. of "The Electrician," price 10s. 6d., is now ready. Also cases for binding, price 2s.

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A SCIENTIFIC PROFESSION.

Judging by the numerous inquirers who have lately invaded our privacy, we are led to believe that a fresh trouble has overtaken the heads of families at this trying time of the year. Young men are coming home, many of them for the *very* long vacation—that is to say are leaving school for good, and are eligible for situations comparatively few in number, and the candidates for which are extremely plentiful. Education is no longer a scarcity in the market; and, added to those ailments which afflict us at Yuletide, commonly classed under the generic term Christmas-Bill-iousness, there has set in a new malady which, with similar levity, might be called Son-stroke, whereby the parent is mentally incapacitated from discovering any suitable employment for his male projeny. We say mentally, because in point of fact there are just as many facilities for obtaining good work as there ever were, in some respects more; the new difficulty being we suspect very largely, though not, perhaps, wholly, due to the higher views which have latterly come into vogue with regard to what constitutes good work, and what is derogatory to the dignity of a well-born and well-educated youth. A respectable and rather high-priced magazine has actually been started exclusively in the interests of the afflicted father, describing in glowing detail the advantages of the several careers open to the sons of gentlemen in this country. These careers are of course all professional, all requiring a liberal education, and some of them commanding wages almost as good as those of a skilled mechanic. They are highly respectable, moreover, and this of itself seems to be the chief attraction for the distracted father of the period.

With the opening up of brilliant prospects for Electric Lighting industry there naturally arose an enthusiasm for scientific teaching never before exhibited, in order that the rising young man might qualify to enter upon this new and lucrative career. And, notwithstanding the many disappointments it has encountered, "Electric Lighting of the future" still possesses many attractions for the anxious parent whose sons apparently were born into the world just in the nick of time, and with no other aim than to further the progress of the new illuminant. We need not state what respectively has been the advice we have tendered in the many cases laid before us. Suffice it to say, we are not responsible for the incompetent doings of the half-trained and wholly inexperienced persons who have already contrived to shipwreck more than one undertaking which in better hands might have been examples of brilliant success. This has come about through people meddling with electricity whose knowledge was mainly confined to engineering, or who knew something of electricity but not enough of engineering. Perhaps in the then condition of the educational market these catastrophes were unavoidable. All we say is that we had no hand in them. If any of our friends have blundered into unenviable notoriety, it has been through yielding not to our advice, but to their own rash impluses.

Some appropriate remarks on this subject were made by Sir Frederick Abel when distributing prizes at the Crystal Palace School of Practical Engineering last Saturday. Contrasting the opportunities of such men as Stephenson, Fairbairn, and Whitworth with those of the modern student, he pointed out that whereas only 12 years ago, when the work of technical education had hardly begun, there were only 202 persons who submitted themselves for examination, there are in the present year close upon 4,000. This is highly encouraging; but it was appropriately added that formerly men who rose to eminence like those mentioned above had to labour like working men in the hardest sense of the term, and at the same time had to acquire that knowledge which afterwards enabled them to fill such brilliant positions in the world. The statement is even truer to-day than it was formerly. To rise to eminence in any of the professions of applied science it is necessary to stoop to toil and not be ashamed of it. Scholarship has now, as ever, an important part to play; but, contrary to what is vainly imagined by the genteel parent, it is a part which few can play to perfection, and which it would be as absurd to choose for "a profession" as to "choose" to be a genius. If the student has genius to begin with, he will develop it in a fitting direction, whether in theory or practice—possibly in both. But young men whose parents have to find out a career for them are not usually geniuses; and what they have got to do is to work up to their proposed career, which is not attained by a fastidious regard for unsoiled fingers, or a languid preference for book learning. The field of science grows wider in every age, and an acquaintance with every corner of it becomes more and more unattainable except by the rarely gifted. But a practical knowledge of any given area is possible for every one who is endowed with diligence and not handicapped by pride. The science and the theory may be had simultaneously, or subsequently, according to the individual's capacity. But for earning a living, practical knowledge is the first and indispensable requisite.

To put a young gentleman in the workshop as a beginning is about the last thing the modern parent or guardian now thinks of doing. Yet in the majority of cases it is the very

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best thing to do. If the candidate is naturally studious he will be none the less so, but more healthfully so, by throwing a good spell of handicraft into the bargain. As to his character, if he is what he professes, he will not lose caste in the workshop; quite the contrary; he will be respected while there, and if successful in after life, will be more highly esteemed for having started fair with the common workman. If there is nothing uncommon in him, nothing above the average labourer, then depend upon it his mediocrity will prove less disastrous than if he were thrust into the profession higher up the ladder only to drop from it a pretentious failure. There are abundant examples of showy scientism coming to grief when put to practical test; and not a few of ludicrous failures by eminent theorists unable to realise their conceptions in practice. But the practical man, if he flies not so high, is sure of his wings, and will alight safely. The thinker will always be the pioneer of the worker, and is mentally his superior; but in selecting a profession it is safer to reckon on what a man can do than on what he may think; and a working beginning will at all events not unfit any man for the exercise of his higher faculties later on. To all of our readers, and especially to such as have the cares of a growing male family on their minds just now, we heartily wish a Merry Christmas—to which the foregoing observations may, we hope, in some degree contribute.

CORRESPONDENCE.

CURRENT INDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Whilst Prof. T. A. Smith's *confrères* are giving their criticisms on the careful and interesting experiment he recounts (p. 111), will you kindly allow me space for a few words myself. Is it not a very striking fact that the only person who has taken up this question and dealt with it face to face is Prof. Smith, at a distance of some 4,000 miles? It is because a transatlantic mind is in advance of Great Britain in its wide receptiveness for what is new, and possibly true, that the Professor grants both a patient hearing and a considered judgment to a heresy bearing some marks of serious reasoning. As to the experiment itself, it is like one which Mr. Edgar Smart carried out some weeks ago, in which, however, an iron core was used. With apparatus improvised at home I have never succeeded in making a satisfactory experiment without the intervention of iron.

There is a good deal to say and to ask about the American experiment, but considerations of space urge me to defer my remarks.—Yours, &c., E. ALDRED WILLIAMS.

37, Burlington-road, W., Dec. 19, 1885.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Amongst the "Notes" of your previous number there is one headed "In the Organic World," and you write "We have an electric plant, an electric bug, an electric slug, and three electric fishes." Why was the electric boy not included in this list? Was he not exhibited in London? He was exhibited in Edinburgh for a long time, and advertised in the newspapers. When I first saw the advertisement I considered it a trick of some showman, therefore did not go near the exhibition; but after meeting with a friend, a scientist, who had seen the boy, I went to see him. He was then exhibited in one of the small stalls in the gallery of the market in Princes-street. I found there a little black boy in charge of a white man. There was no furniture in the stall but a couple of wooden seats and a small piece of carpet to keep the boy's bare feet off the floor. There was therefore nothing wherewith to conceal any electrical apparatus. As I was at that time the only visitor I had the boy stripped naked and was satisfied there was nothing outside of his skin that could produce electricity. While thus naked he walked in my presence, and also sat on the wooden seat with his feet off the ground. In every position in which I tried him I found electricity proceeded freely from his body when I touched it with one finger. The electricity came with the greatest freedom from the upper half of his body, and especially from his tongue. Although I felt a slight shock in my finger when I touched his tongue he did not seem to feel any; his tongue did not quiver and he did not offer to withdraw it. I thereon asked him if he did not feel anything unpleasant when I touched his tongue. He replied, No! This surprised me much, because when an ordinary person is placed on an insulated stool and there surcharged with electricity and then touched by an uninsulated person, both parties feel the passage of the electricity unpleasant; but not so this boy. He seemed to be so full of electricity that the passage of it from his body gave him no more uneasiness than the passage of perspiration from him.—Yours, &c.,

JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, Dec. 21, 1885.

ELECTRIC BELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In experimenting on the short-circuit method of working electric bells, I have invariably found that it produces a very much feebler motion of the hammer than the ordinary method of making and breaking the circuit affords. The construction of these short-circuit bells is given in the articles on "Pratical Telephony" (p. 189, Vol. XI. of *The Electrician*), so perhaps some of our telephonic friends can explain the reason, and the remedy if there be one?—Yours, &c., J. W. J.

Birmingham, Dec. 18, 1885.

ELECTRICITY IN WARFARE.*

The first practical plan for using electricity in warfare was devised and executed by Col. Samuel Colt, the inventor of the revolver, who, in 1841, wrote to President Tyler, stating that he had invented an apparatus by means of which he could destroy in a moment the most powerful man-of war, even though miles away, and asking that the Government give him opportunity for demonstrating the truth of his statement. The truth of his statement he demonstrated a year later by exploding a "torpedo" under water, in New York harbour, by means of electricity. Following up this success, he totally destroyed, by similar means, an old gunboat named "Boxer," and six weeks later, in sight of the President, General Scott, and others, he destroyed a schooner in the Potomac, distant five miles. Congress at once appropriated 17,000 dollars to continue his experiments and perfect his apparatus; and in two months from this time he blew up the big "Volta" in New York, in the presence of forty thousand spectators. All of these vessels were at anchor; but in the spring of 1843 Col. Colt demonstrated the further value of his invention by blowing up a vessel while under way in the Potomac, he being at Alexandria, five miles distant. These performances seemed in that day little short of magic, and their practical value was evident to many, yet they stopped short at this point, and were never resumed. Col. Colt endeavoured to get further assistance from the Government, but without success. From a variety of reasons, the authorities regarded his plans with disfavour, and Colt, disheartened and distressed, was compelled to abandon his invention just at the time when its success was assured but its details unperfected. But the Russians caught his ideas, and in the Crimean War we find the harbour of Sebastopol defended by torpedoes, many of which were operated by electricity. A few years later, in our Civil War, the electrical torpedo was extensively used by the Confederates in the protection of their harbours. In the Franco-Prussian

* Lecture delivered before the Franklin Institute, November 13, 1885, by Lieut. B. A. Fiske, U.S. Navy.

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War torpedoes were so successfully employed in the defence of harbours that hostile ships did not even attempt to enter them; and in the Turco-Russian War, the mere suspicion that a harbour was defended by torpedoes was enough, in many instances, to keep a hostile fleet at a surprising distance—for the hostile fleet could not know just how far beyond a harbour the torpedo defence extended.

Since the experiments of Col. Colt the electrical torpedo has gradually improved, keeping pace with the progress of the sciences of electricity and engineering. Yet the original plan is the basis of the most elaborate and perfect instrument, and to the brain of Col. Colt we owe the surest defence we have for the cities and harbours of our extensive coast. At the present day an electrical torpedo consists of a strong, water-tight vessel of iron or steel, which contains a large amount of explosive, usually gun-cotton, and a device for detonating this explosive by electricity; and the most important form is that form which is anchored in a channel, and which is made to explode when an enemy's ship passes near it. These torpedoes are usually called "submarine mines." In our war most of these torpedoes were not operated by electricity, but by mechanical means, which consisted, for the most part, of levers protruding outside the case, and so connected with the explosive inside that when a lever was struck by a passing vessel a hammer inside was caused to fall upon a cap, just as when the trigger of a musket is pulled a hammer is caused to fall upon a cap. These mechanical torpedoes were used with considerable success by the Confederates, and they caused tremendous damage to the Union ships; but they had a number of defects, on account of which they have been almost entirely supplanted by the more complete, though much less simple, electrical torpedo. One of the defects of mechanical torpedoes was the danger attending the operation of planting them; another was the danger attending the operation of raising them; another was the fact that it was impossible to tell whether they remained in order, save by the expensive and suicidal plan of seeing if they would explode; and still another defect was that a mechanical mine did not know a friendly ship from a hostile one, but would sink either with absolute impartiality.

Now, it is clear that an electrical torpedo is free from all these defects, because it cannot be exploded unless a current of electricity be sent through it from a battery on shore or on board ship, so that the only thing to do when it is desired to make it harmless is simply to disconnect the battery; and when it is desired to put the mine into operation again the only thing to do is simply to reconnect the battery; moreover, the condition of the mine can at any time be determined by sending a very minute current through it, even though the torpedo be miles away, and buried in water many fathoms deep. In order to understand how electricity can explode a torpedo, it is sufficient to know that when a current of electricity goes through a wire it heats it to some extent, and if the wire be small enough the heat produced is sufficient to make the wire white hot. Clearly, if powder or fulminate of mercury be in contact with a white-hot wire, the powder or fulminate will be ignited, and if this powder or fulminate be enclosed in a tight vessel, together with powder or gun cotton, a tremendous explosion will ensue. Therefore, in order to explode a torpedo, the only thing necessary is to send a current of electricity through a very small wire, preferably of platinum, which is within the torpedo, and in contact with the explosive. The part of a torpedo which includes this small wire and its connections is called the fuse. In practice, the fuse is a separate thing, and is screwed into the torpedo case, the wire from the battery coming in through the fuse through a water-tight gland, so that, after the fuse has been screwed in, the torpedo, as a whole is water-tight, and may be left under water for months without injury. If the explosive charge is wet gun-cotton, as is now usually the case, the fuse contains fulminate of mercury, and is surrounded by a small charge of dry gun-cotton. The heat of the fuse-wire explodes the fulminate, the explosion of the fulminate causes the instant explosion of the dry gun-cotton, and this, in turn, causes the instant explosion of the whole charge of wet gun-cotton in the torpedo. But it is evidently not sufficient to be able to explode a torpedo; we must also know when to explode it, that is, we must know when the hostile ship is in such a position that she will be destroyed if the torpedo is exploded. Clearly, we can know this if we have a chart showing the exact position of each torpedo, and have also an arrangement by which we can know at any instant the bearing of a ship coming up the channel from two stations properly situated. If the ship comes into such a position that she is in the line of one of the torpedoes as seen from each station, she is clearly on the intersection of those lines, and is therefore directly over that torpedo, and the only thing necessary is to touch the electric key controlling that torpedo, thus sending an electric current through its fuse and causing its instant explosion. Another way is to have the telescopes at the two observing stations so fitted that when both point at any torpedo the current is automatically sent through that torpedo. Therefore, if the observer at each station keeps his telescope bearing on an advancing ship, electricity will do the rest, and the ship will sink when she comes within the radius of destructive effect of any one of the torpedoes

But what can be done at night, or in a dense fog? Evidently these systems will not answer then, because a ship cannot then be seen; and for this reason torpedoes now are frequently made absolutely automatic, so that whether the time be day or night, clear or foggy, the mere fact of a ship's striking a torpedo is sufficient to ensure her instant destruction. This result is secured by the use of what is known to electricians as an automatic circuit closer, that is, a device which, when subjected to certain conditions, automatically bridges over the distance between two points which were separated, thus allowing the current to pass between them. In submarine torpedoes it is usual to employ a small weight, which, when the torpedo is struck, is thrown by the force of the blow across two contact points, one of which points is in connection with the fuse, the other in connection with the battery, so that the current immediately runs over the bridge thus opened and through the fuse. In practice, these two contact points are connected by a wire, even when the torpedo is not in the state of being struck; but this wire is of such great resistance that the current is too weak to heat the wire in the fuse. Yet, when the weight above mentioned is thrown across the two contact points, the current runs across this bridge instead of through the resistance wire, and is then strong enough to heat the wire in the fuse and explode the torpedo. Now, the advantage of having a wire of high resistance between the contact points, instead of having no wire between them, is that the current which then passes through the fuse, though too weak to fire it, shows by its very existence to the men on shore that the circuit through the torpedo is all right. But instead of having the increased current, caused by striking the torpedo, to fire the torpedo directly, a better way is to have it simply make a signal on shore, and at the same time throw in a firing battery. Then, when friendly vessels are to pass, the firing battery can be disconnected, and when the friendly ship bumps the torpedo the working of the signal shows not only that the circuit through the fuse is all right, but also that the circuit-closer is all right, so that had the friendly ship been a hostile ship she would certainly have been destroyed. The action of a torpedo placed in the harbour and connected by a submarine cable to an electric battery or shore is thus shown to be quite a simple thing. But it should not be gathered from this that the protection of a harbour is a simple thing, or one that could be accomplished in a few days on the outbreak of war. It should be remembered that each torpedo contains from 100 to 1,000 pounds of gun-cotton, that hundreds of torpedoes will have to be used, that the amount of gun-cotton required will be enormous, and that it will be wanted in a hurry, but that the operation of making gun-cotton cannot be hurried. It must be remembered that to make the torpedo cases required will consume much time; that the making of the fuses is a matter requiring the greatest possible care and calculation; that the operation of properly laying down these heavy, and yet delicate, torpedoes, in deep water, even in the best possible weather, is an operation requiring great nautical and engineering skill and practice. Yet,

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even after the best system of submarine mines has been laid down, it will be of no use unless an enemy's boats can be kept from counter-mining, and unless the operating rooms be furnished with the best instruments and thoroughly protected against capture by fortifications, guns, and ships. It is no uncommon thing to hear men of intelligence airily say, "Oh, in time of war we can defend our harbours by torpedoes." I do not think I am exaggerating when I say it would take a year to put the torpedo defences of our harbours into proper shape, even if Congress were to appropriate the money to-morrow. And after that a corps of men would have to be formed and thoroughly trained in laying down and taking up torpedoes and cables, making splices in submarine cables, testing circuits, managing electric batteries, &c.

In order to detect the presence of torpedoes in an enemy's harbour, an instrument has been invented by Captain M'Evoy, called the "torpedo detector," in which the action is somewhat similar to that of the induction balance, the iron of a torpedo case having the effect of increasing the number of lines of force embraced by one of two opposing coils, so that the current induced in it overpowers that induced in the other, and a distinct sound is heard in a telephone receiver in circuit with them. As yet this instrument has met with little practical success, but, its principle being correct, we can say with considerable confidence that the reason of its non-sucess probably is that the coils and current used are both too small.

Besides these stationary torpedoes or mines anchored in harbours, there is another class, called spar torpedoes, which are carried on spars protruding from ships or boats, and which consist for the most part of cases of steel holding about 30 pounds of gun-cotton, and fitted with electric fuses similar to those for exploding submarine mines. The torpedo on the end of the spar is connected by insulated wires with an electric battery in the boat or ship, and it is designed to be shoved under a hostile ship by a determined effort and exploded there. The current is sent through the fuse by pressing an electric key at the proper moment, or a simple automatic circuit-closer may be put inside the torpedo, so that when the torpedo strikes the ship a break in the circuit is automatically bridged over in the torpedo, thus allowing the current to heat the platinum wire in the fuse, and explode the torpedo.

Still another class of torpedoes are movable torpedoes. These contain not only explosive and means for exploding it, but also machinery for moving the whole through the water, and for steering it. A movable torpedo is, therefore, really a torpedo boat and torpedo combined. In one class of movable torpedoes, such as the Lay torpedo, the motive power is usually carbonic acid gas or compressed air, the steering and firing being done by electricity. One wire usually suffices, a simple step-by-step device accomplishing the operation of sending the current through different circuits in the boat, the current through one circuit causing the throttle of the engine to open, the current through another causing it to close, another putting the helm to starboard, another putting the helm to port, another firing the torpedo, &c. Therefore, the operator on shore or on board ship can, by moving his switch in the proper manner, cause the torpedo boat to go ahead, stop, turn to the right or left in such a way as to go directly toward the object of attack and then explode in contact with her bottom.

In another class of movable torpedoes the electric current not only steers the boat, but also propels it, there being an electric motor—or engine—inside, which, when supplied with the requisite current from an electric machine on shore or on shipboard, revolves rapidly, thereby causing the propeller of the boat to revolve in the same way that a steam engine causes the propeller of a steamboat to revolve. The current for steering may either be sent along a separate wire, which may be inside the other one, or a device may be used by which one wire will suffice for everything. Movable torpedoes being usually cigar-shaped, so that their section is circular, or nearly so, the electro-motor for an electric movable torpedo which will most nearly fit the space intended for it—in other words, the shape which permits the largest size for a given space—is clearly one in which the distance from the centre of the armature to the outside of the magnets is constant, so that the field-magnets form nearly a circle embracing the armature. The exterior form of the motor called the Griscom motor evidently seems to fulfil this condition well. The most successful movable electric torpedo thus far tried is the Sims torpedo, with which experiments have been conducted under General Abbot's superintendence for some time, and with very good results. Now, as all men-of-war and all forts are to be supplied with means for generating electricity on a large scale, it is clear that an electric movable torpedo can be easily adapted to naval and military requirements, the mechanism of the torpedo being exceedingly simple, and the only thing to be done to put it into operation being to connect it to a suitable electric machine, and introduce a keyboard, by which the direction and strength of the current can be controlled. The torpedo will then be ready to move at any instant, and will have a supply of power practically inexhaustible. Recent experiments in England have shown that the Whitehead torpedo—over which control ceases after it is fired—is not so formidable a weapon when fired at a ship under way as many supposed, for the simple reason that it can be dodged. Now, an electrical torpedo, over which control is exercised while it is in motion through the water, cannot be dodged, provided it be given sufficient speed. For effective work against ships capable of steaming fifteen knots per hour, the torpedo should have a speed of twenty knots. Now, there is no theoretical difficulty in the way of doing this, for a speed of 11 knots has already been recorded, though an electric torpedo, to get this speed, would have to be larger than a Whitehead having the same speed; and it may be conceived that a torpedo carrying, say, 50lbs. of gun-cotton, capable of going 20 knots per hour—so that it would pass over a distance of 500 yards in about 45 seconds, and yet be absolutely under control all the time, so that it can be constantly kept pointed at its target—would be a very unpleasant thing for an enemy to meet. Our civil war introduced another use of electricity into warfare, and gave birth to the art of military telegraphy. At first, the telegraph was used only in communicating along the regular telegraph routes, but eventually a corps of military telegraphers was formed, and instant communication became possible between detachments in the field. The advantage of the telegraph in conveying information and orders with despatch was found to be so great that foreign nations took the hint, and to-day a telegraph train is essential to all armies. No well-equipped force in the world is without means for rapidly connecting by the telegraph different head-quarters with each other, and with the different parts of an army; and in the Franco-Prussian war it was the telegraph, combined with the railroad, which made possible that wonderful speed and certainty of mobilisation and manœuvre that caused the swift destruction of the armies of France. In military telegraph trains, miles of wire are carried on reels in specially constructed waggons, which carry also batteries and instruments, some of the wire being insulated, so that it can rest on the ground, and thus be laid out with great speed, while other wire is bare, and is intended to be put on poles, trees, &c. For mountain service the wires and implements are carried by pack animals. Regularly trained men are employed, and they are drilled in quickly running lines, setting up temporary stations, &c. In the recent English operations in Egypt the advance guard always kept in telegraphic communication with head-quarters, and with England; and after the battle of Tel el-Kebir, news of the victory was telegraphed to the Queen, and her answer received in forty-five minutes. The telephone also has been used in military operations, and with great sucess; having an evident superiority over the telegraph for some purposes. One use of the telephone, in fact, is to assist the telegraph in cases where by reason of the haste with which a line has been run, the current leaks off, so that the receiving instrument will not work. The only thing necessary is to use a telephone to receive the message, and to use as a transmitter a simple buzzer, or automatic circuit breaker, controlled by an ordinary key. In many cases, where the ordinary receiving telegraph instrument refuses to work, the more delicate telephone thus used will work very satisfactorily. In endeavouring to use the telegraph and telephone for strictly naval purposes between ships, a number of obstacles have been met which have not

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yet been overcome, though many ingenious devices have been attempted. It might seem at first sight as if, in the case of ships at anchor, telegraphic and telephonic communication among the ships and between the ships and shore would be an easy thing to establish. It is easy, and it has been established in the case of ships moored so that they cannot swing; but when a ship swings by a long chain, most of which is embedded in the mud, it becomes very difficult to devise an automatic means to keep the wire from being fouled and broken. In England, in the case of lightships, the difficulty has been surmounted, or rather avoided, by making the cable by which she rides hollow, and running an insulated wire along the long tube thus formed inside. This plan has been found thus far to work very well, even in the worst sort of weather. But the problem is much simplified when temporary communication only is desired between ships at anchor, between a ship and the shore, or between a ship and a boat which has been sent off on some special service, such as reconnoitering, sounding, &c. In this case portable telephones are used, in which the wire is so placed on a reel in circuit with the telephone that communication is preserved, even while the wire is running off the reel. The telephone has been used to some extent on shipboard for communicating between different parts of the same ship, giving orders to the magazines, battery, &c. The vibration of a ship is seldom so excessive as to impair the working of the microphone transmitter; and, in cases where it is excessive, the original magneto-transmitter has been found to work perfectly, getting rid entirely of trouble due to vibration, and at the cost of only a little of the loudness of tone as heard in the receiver. The telegraph and telephone are both coming largely into use in artillery experiments and drills, as in tracking a vessel as she comes up a channel, so that her exact position at each instant is known, in determining the spot of fall of a projectile, &c. In these cases two observers at the end of a base line electrically connected know at each instant the bearing of the vessel or the projectile from both ends of the base line, and the intersection of these lines of bearing is, of course, the position of the vessel or the projectile at that instant. In the case of a vessel this gives the range for the guns, and in the case of a projectile it shows by how much the projectile missed the target. In getting the time of flight, also, of projectiles, electricity is of value, since it enables the observers to get the exact time of start, a thing impossible to get with stop watches; but by making the projectile break a wire in circuit with a chronograph, the precise instant of start, to a thousandth of a second at least, is automatically registered. An application of electricity somewhat analogous to this has been in use for years in what are broadly called velocimeters, that is, instruments for ascertaining the velocity of projectiles. There are scores of patterns, but in all wires are cut by the projectile at different points of its flight, and the breaking of each wire causes the breaking of the electric current going through it, and this causes the appearance of marks on a surface moving along at a known speed. Now, knowing the rate at which this surface moves, and observing the distance on the surface between the marks cause by the breaking of the first wire and the marks caused by the breaking of the second wire, we can compute the interval of time which elapsed between breaking of the two wires; and now, knowing this interval of time, and knowing also the distance between the two wires, we can calculate at once the velocity of the projectile in going from one wire to the other.

Within the past few years electricity has come to be employed to a great and increasing extent in firing great guns, both on ships and in forts. In the case of ships the advantage of electrical firing lies in the fact that a gun can be fired more quickly by electricity than by other means. The ordinary means of firing are, as is well known, percussion and friction, and in each of these systems the moving parts have to be of such strength that considerable force must be exerted by the arm in order to operate them. Moreover, for prudential reasons, the line leading to them from the hand must be kept very slack, lest a lurch of the ship should cause such a movement of the man's body as to bring a strain on the line sufficient to cause the accidental firing of the gun. Therefore, when the gun captain finds the sights on the gun bear on the target he must then move his arm through a considerable distance, and exert considerable force, before the gun will be fired. It may seem as if the time were insignificant; but when it is considered how rapidly a ship rolls, and how swiftly a modern ship moves, and when it is remembered how small an error in elevation suffices to make a projectile fall short of, or go over, a ship which subtends a very small angle in a vertical plane, it will be seen that a fire which comes instantaneously with the coincidence of sights and target is better than one which does not. Now, in firing by electricity, the gun captain holds a sort of push-button in his hand, which he simply presses, when the sights bear on the target; and practical experiments abroad have shown that greater accuracy is attainable by this method than is attainable by the old methods. But not only are modern vessels of war fitted with means for electrically firing individual guns, they are also fitted with means for firing any desired number together, the whole broadside even; for the effect upon an enemy of a blow from a whole broadside at once, is very much greater than the effect of the same number of guns fired at different times. The simplest way of doing this is to lead the electrical wires from all the guns to an armoured fighting tower, where a cool officer, under the personal direction of the commander, with an electrical key board and a good system of sights, can deliver the whole fire of the broadside at once upon an enemy.

This officer being clear of the smoke and away from the excitement and bustle of the battery, and with a view of the whole horizon, can clearly handle the battery with its maximum effectiveness; and, moreover, as soon as the guns have been laid at the range and in the direction at which it is intended to fire them, the men can lie down and be protected in a measure from the murderous fire of machine guns. Suppose that two modern ships are about to engage in a naval duel on the high seas, and that they are advancing towards each other at a speed of 14 knots an hour each, so that they are coming together at a rate of about 46ft. per second. The ships will, of course, begin to play on each other with their machine guns as soon as they get within range, so that as soon as the great guns are ready, the men had best be made to lie down on the deck, in rear of their guns. Now, the battery of each ship will probably be composed of guns firing projectiles of from 100lb. to 1,000lb., and each commander, knowing how much damage can be done by one well-delivered shot, knowing how long it takes to reload a modern gun, and appreciating the great speed at which the ships are approaching, will probably reserve his fire until sure that he has a good chance of making every shot tell. He will hardly fire at 2,000 yards range, knowing that his chance of hitting the rapidly moving target is small, and knowing that it will be only about one minute before the enemy will be at 1,000 yards range. Now, at 1,000 yards range, the machine guns of both ships will be working vigorously, and each ship will have an excellent target, but a target improving so rapidly that a commander would not wish to throw away all the shot of his great guns until a closer range is reached. One gun, for instance, might be fired now, having been previously laid for this range, of course; but probably it would be best to reserve nearly the whole broadside to be delivered simultaneously as the ships rush by each other at pretty close range. With the heavy guns and carriages of the present day, it would be impracticable to keep a gun pointing at a ship under these circumstances, since both range and bearing are changing so rapidly. Therefore, the guns must be pointed in certain directions and laid for certain ranges, and fired when the enemy reaches the spots thus defined.

In the case of a fort the value of firing by electricity is evident, since it can be employed in connection with the instruments used for determining at each instant the position of an approaching vessel or army. Different guns being laid at different ranges and in different directions, an officer in the operating rooms can keep track of the exact position of the enemy, and when the enemy reaches one of the predetermined points, all he has to do is to touch an electric key and fire the gun or guns controlled by that key, knowing that those guns

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are not only pointed in the proper direction, but also are elevated for the correct range. It would seem difficult to improve upon the accuracy obtainable by this method.

Whitehead torpedoes are now so arranged that they can be ejected by pressing an electric button; and the firing keyboard in the fighting tower of a ship indicates at any instant what guns and torpedoes are ready for firing. The fighting tower should also be fitted with engine and steering telegraphs, and indicators for showing whether the commander's orders to the engine and steering apparatus have been understood and executed, so that the commander can tell at a glance the exact state of affairs at battery, engine, and steering apparatus, and can have all the separate departments of his ship under absolute personal control.

Within the past three years the superiority of the incandescent electric light over all other lights for ship use has become more and more evident, and nearly all first-class merchant steamships launched, and all men-of-war, are fitted with electric lights. In men-of-war this light has even more advantages than in merchant ships by reason of its safety in illuminating magazines, shell rooms, torpedo store rooms, &c., and the ease and speed with which it can be used in signalling at night.

For some time the electric light was declared unsuitable for naval use, the reason being urged that if the wire carrying the current should be shot away in action, the whole ship would be plunged into darkness, and that the same thing would happen if any accident should befall the dynamo generating the current.

The answer to this very sensible criticism is that, first, different circuits must be arranged for different parts of the ship, so that an accident in any part of the ship will affect that part only; second, that the wires carrying the current must be arranged in duplicate, so that even in case one wire is shot away, the lights will burn as brightly as ever, since the other wire remains, and is of sufficient size to carry all the current; third, it is very easy to repair a break in a copper wire, even if it be shot away, the only thing necessary being to bridge over the break by a wire a few inches long, whose ends can be clamped, spliced, or even twisted on to the broken conductor on each side of the break.

(To be continued.)

PHYSICAL SOCIETY.—December 12th.

Prof. GUTHRIE, President, in the chair.

Mr. C. F. Casella and Prof. T. E. Thorpe were elected members of the Society.

The following papers were read: "On a Magneto-Electric Phenomenon," by Mr. G. H. Wyatt. The author had conducted a series of experiments with a view of testing experimentally an expression obtained by Mr. Boys for the throw of a copper disc suspended by a torsion fibre between the poles of an electromagnet, when the current was made or broken, and communicated by him to the Society on June 28, 1884. Discs of various metals and of various dimensions were used, the results being such as to agree with the theory within narrow limits. It was, however, found that when the throw of the disc was used to measure the magnetic field, the value obtained from the throw at break was uniformly greater than that obtained on making the current.—Prof. S. P. Thompson observed that the case presented was analagous to that of the ballistic galvanometer, and that for the theory it was necessary that the magnetic field should be made and destroyed before the disc had moved sensibly. Mr. Boys believed that the results of the experiments showed this to be the case, since the result of such a movement would be to increase the throw on breaking the current, when the disc made an angle of less than 45deg. with the lines of force, and to decrease it when the angle was between 45deg. and 90deg. whereas no such variation from the theoretical result was observed.

"On Some Thermodynamical Relations," by Prof. William Ramsay and Dr. Sydney Young. In this paper experimental proof is given of the following relations:—(1.) The amount of heat required to produce unit increase of volume in the passage from the liquid to the gaseous state, at the boiling point under normal pressure, is approximately constant for all bodies. (2.) If these amounts of heat be compared at different pressures, for any two bodies, then the ratio of the amount at the boiling point under a pressure p_1 to the amount at another pressure p_2 is approximately constant. (3.) The products of the absolute temperature into the rate of increase of pressure with rise of temperature are approximately the same for all stable substances. (4.) The rate of increase of this product with rise of pressure is nearly the same for all stable substances. (5.) A relation exists between the absolute temperature of all bodies, solid or liquid, stable or dissociable, which may be expressed in the case of any two bodies by the equation

$$\frac{T_a}{T_b} = \frac{T'_a}{T'_b} + C(T'_a - T_a),$$

T_a and T_b being the absolute temperatures of the two bodies corresponding to any vapour-pressure, T'_a and T'_b absolute temperatures at any other pressure, and c a constant, which may be zero, or a small positive or negative quantity. (6). The variations from constancy of the expression $t\frac{dp}{dt}$, though small, may be expressed by a similar equation. (7.) If L_a, L'_a, L_b, and L'_b, represent similar relations of latent heat at different pressures the same for a and b, it appears probable that

$$\frac{L_a}{L'_b} = \frac{L_b}{L'_b} + C(T'_a - T_a).$$

(8.) The ratio of the heats of vaporisation of any two bodies at the same pressure is approximately the same as that of their absolute temperatures at that pressure. The authors conjecture that this statement is also true of dissociating bodies. A large part of the experimental work consisted in obtaining the relation between vapour pressure and temperature of different substances, values of $\frac{dp}{dt}$ had been obtained from these observations in two ways, by plotting curves with t and p as co-ordinates and drawing tangents, and by the method of differences.—Prof. Perry suggested that the curve should be expressed in such a form as—

$$\text{Log. } p = d - \frac{\beta}{t} - \frac{\gamma}{t^2}$$

which Rankine has shown to be a very true expression for the relation between pressure and temperature, and that $\frac{dp}{dt}$ should be obtained from this by differentiation.—Prof. Guthrie hoped the authors would experiment upon the vapour-tensions of mixed liquids, a subject to which he had himself given some attention.

LIGHTHOUSE ILLUMINANTS.—ELECTRIC LIGHT APPARATUS.

REPORT OF PROF. W. GRYLLS ADAMS, F.R.S., &c.

(Concluded from page 117.)

2. If the rays after leaving the lighthouse lens are not absolutely parallel, but slightly divergent, so that they apparently come from a point farther off than the source, by a distance x,

Then $u = x + l$; and if u_1 be the distance of the source of light from the lighthouse lens, then u_1 and x are the distances of conjugate foci from this lens.

$$\text{Hence } L = \lambda \left(\frac{r-a}{d-r}\right)^2 \times \frac{c\,c_1}{f^2} \times \frac{(x+l-f)^2 u_1^2}{x^2} \times \frac{1}{a};$$

$$\text{but } \left(\frac{f_1 - u_1}{f_1}\right)^2 - \frac{u_1^2}{x^2} = \frac{f_1^2}{(x+f_1)^2}\left(\text{since } \frac{1}{u_1} - \frac{1}{x} = \frac{1}{f_1}\right).$$

Hence for a divergent beam,

$$L = \lambda \left(\frac{r-a}{d-r}\right)^2 \times \frac{c}{f^2} \times c_1 f_1^2 \left(\frac{x+l-f}{x+f_1}\right)^2 \times \frac{1}{a^l},$$

or

$$L = \lambda \left(\frac{r-a}{d-r}\right)^2 \times \frac{c}{f^2} \times c_1 f_1^2 \frac{\left(u_1 + \frac{f_1 - u_1}{f_1}(l-f)\right)}{f_1^2} \times \frac{1}{a^l},$$

$$= \lambda \left(\frac{r-a}{d-r}\right)^2 \times \frac{cc_1}{f^2}\left(u_1 + \frac{f_1 - u}{f_1}(l-f)\right)^2 \times \frac{1}{a^l}.$$

For a converging beam the value of

$$L = \lambda \left(\frac{r-a}{d-r}\right)^2 \times \frac{cc_1}{f^2}\left(u_1 - \frac{u - f_1}{f_1}(l-f)\right)^2 \times \frac{1}{a^l}.$$

These formulæ are very convenient for estimating the intensity of the source of light in the experimental towers when photometric observations are made by means of the achromatic lens in hut 2. For the Mew Island lens $f_1 = 920$ millimetres $= 36{\cdot}22$ inches;

$l = 6200$ft. $(f_1 - u_1) =$ the distance of the source of light from the principal focus of the lens.

$f = 7{\cdot}593$ft.
$c = 1{\cdot}414$ for the achromatic lens.
$c_1 = 1{\cdot}15$ for the lighthouse lens.

The value of a depends upon the transparency of the atmosphere.

To apply the formulæ for the intensity for different diverging and converging beams, when the photometric observations are made at hut 2. Supposing the arc strikes across at the edge of a 40mm. carbon—

$f_1 = 920$mm., or $3{\cdot}02$ft. nearly. $u_1 = 900$mm.

$$\frac{f_1 - u_1}{f_1} = \frac{2}{92} = \frac{1}{46} = {\cdot}02174$$

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$$\left(u_1+\frac{f_1-u_1}{f_1}(l-f)\right)^2=\left(3+\frac{1}{46}\times 6200\right)^2=138^2=19,000 \text{ nearly.}$$

For the M.I. lens with the arc 2 inches or ·167ft. out of focus in focal plane—

$$\frac{f_1-u_1}{f_1}=\frac{\cdot 1666}{3\cdot 018}=\cdot 055347.$$

$$\left(u_1+\frac{f_1-u_1}{f_1}(l-f)\right)^2=(2\cdot 85+342\cdot 8)^2=119,400.$$

$$\frac{f_1-u_1}{f_1}(l-f)=342\cdot 8\text{ft.}$$

$$L=\lambda\left(\frac{r-a}{d-r}\right)^2\cdot\frac{cc_1}{f^2}\times\{119,400, \times\frac{1}{al} \text{ nearly.}$$

For the M.I. lens with the arc 4 inches out of focus—

$$\frac{f_1-u_1}{f_1}=\frac{\cdot 33}{3\cdot 018}=\cdot 11074, \text{ and } \frac{f_1-u_1}{f_1}(l-f)=685\cdot 3\text{ft.}$$

$$\therefore\left(u_1+\frac{f_1-u_1}{f_1}(l-f)\right)^2=(2\cdot 69+685\cdot 3^2)=473,340.$$

For the M.I. lens 6″ out of focus in focal plane—

$$\frac{f_1-u_1}{f_1}=\frac{\cdot 5}{3\cdot 018}=\cdot 1657, \text{ and } \frac{f_1-u_1}{f_1}(l-f)=1026\text{ft.}$$

$$\left(u_1+\frac{f_1-u}{f}(l-f)\right)^2=(1028\cdot 5)^2=1,057,000.$$

For the M.I. lens 8″ out of focus in focal plane—

$$\frac{f_1-u_1}{f_1}=\frac{\cdot 6}{3\cdot 018}=\cdot 2210, \frac{f_1-u_1}{f_1}(l-f)=1,368.$$

$$\left(u_1+\frac{f_1-u_1}{f_1}(l-f)\right)^2=(1370\cdot 3)^2=1,878,000.$$

Suppose $f_1-u_1=18\cdot 4$mm., or that the light comes from near the outer edge of a 40mm. carbon—

Then $\frac{f_1-u_1}{f_1}=\frac{1}{50}$.

$$l-f=l \text{ nearly,}$$

and $\left\{u_1+\frac{f_1-u_1}{f_1}(l-f)\right\}^2=\left(3+\frac{1}{50}\times 6200\right)^2=(3+124)^2=16,130.$

The value of the multiplying factors $\delta^2=\left(u+\frac{f-u}{f}l\right)^2$ for a diverging beam, and $\gamma^2=\left(u-\frac{u+f}{f}l\right)^2$ for a converging beam for a source of light placed at a distance $(f-u)$ from the principal focus of a lens of focal length f are given for every centimetre in the following table for a first order lens whose focal length is 92 centimetres. When the source of light is a point accurately in the focus of the lens, the multiplying factor = 10. For a distance of 1 mm. from the focus the value is about 100.

Values of $(f-u)$ in cm.	$\left(\frac{f-u}{f}\right)$	Divergence with M. I. Lens of 60°.	δ^2	γ^2
1	·0109	¾°	4,957	4,150
2	·0217	1½°	18,980	17,380
3	·0326	2¼°	42,070	39,700
4	·0435	3°	74,230	71,120
5	·0544	3⅕°	115,400	111,600
6	·0652	4⅗°	165,800	161,200
7	·0761	5½°	225,200	219,900
8	·0870	6 3/10°	293,600	287,700
9	·0978	7⅙°	371,000	364,600
10	·1086	8°	457,700	450,400
11	·1195	9°	553,700	545,800
12	·1304	10°	658,300	649,500
13	·1412	11°	772,000	762,800
14	·1521	12°	895,000	885,100
15	·1630	13°	1,026,000	1,016,000
20	·2172	18¼°	1,823,000	1,809,000
22	·2390	20½°	2,206,000	2,192,000

With carbons which are 30 mm. or 40 mm. in diameter the striking of the arc leaves ridges and hollows on the surface, which are gradually burnt away, without causing much actual variation, because the arc is scarcely ever accurately in the focus of the lens; thus, for a variation in the distance from 1 cm. to 2 cm. the illumination from the same source is only diminished fourfold, the rate of diminution from this cause increasing at a slower rate as the distance of the arc from the focus of the lens is increased.

If we inquire what is the angle of divergence corresponding to the position of the carbons 2 inches, or about 5 cm., out of focus, with 40 mm. carbons, we find that the angle of divergence varies from 4deg. to about 5½, and that the multiplying factor lies between 120,000 and 225,200; so that a light of 12,000 candles in the "A" tower would give an illumination of from ·1 to ·18 candle at the distance of hut 2, or from 4 to 7½ candles at the focus of the lens in hut 2.

Supposing that the carbons employed are 22 mm. in diameter, then, with an alternate-current machine, the arc may strike across from point to point of the carbons and may be accurately in the focus, or, more commonly, the arc will be formed from near the outer edge of the carbons at a distance of nearly 1 cm. from the focus. Under these circumstances, supposing the atmosphere were absolutely transparent and the light from the arc to be absolutely steady, the illumination at hut 2 might be expected to vary quite one hundredfold simply on account of the almost constant variations of the distance of the arc from the correct focus of the lens. Even supposing the section of the arc is 2 mm. in diameter, the multiplying factor for the light at hut 2 is

$$\left(3\cdot 02+\frac{1}{920}\cdot 6200\right)^2=100 \text{ nearly,}$$

whereas for carbons 2 cm. in diameter, with the arc at the outer edge, this factor is nearly 5,000. If there were no other cause of variation but this, we see that the illumination given at any one point, such as hut 2, through a lighthouse lens from the electric arc must be subject to very great variations of intensity.

Practical Application of the above Formulæ.

Now let us apply these theoretical results to the actual observations made at hut 2 when the arc in "A" tower was placed 2 inches, 4 inches, and 8 inches out of focus.

These experiments were begun on February 27th, and great care was taken on each evening to see either that the carbon was accurately in focus or that it was very accurately placed at the required distance from the focus of the lens. On February 27th the Mew Island lens was placed 8 inches out of focus. The cylindrical lens with vertical prisms was employed for comparison, and, taking the Mew Island lens in focus as giving 12 times the illumination, we get the illuminations of ·45 early in the evening, and ·75 candle at 11 p.m. At hut 2, if the arc be supposed to strike at the edge of the 40mm. carbon, this would correspond to 9,850 candles and 16,350 candles respectively, as the intensity of the source of light (the single arc) in "A" tower, making no allowance for the absorption of light by the atmosphere.

With the Mew Island lens 8 inches out of focus with the arc in the focal plane, the illumination at hut 2 was, in one case, ·004825 candle (185,500), in another ·005322 candle (204,600), and in another ·0039 candle (149,900), which correspond to illuminations of 12,240 candles, 13,500 candles, and 9,850 candles at the arc in "A" tower, as deduced from the above table. The mean of these results does not differ greatly from the mean of the results with the arc in the focus of the lens. The night was a clear one, as the Wigham 108-jet (single) gave an illumination of ·05884 candle at the focus of the lens in hut 2, *i.e.*, ·00143 on the hut (55,460), so that probably the coefficient of the atmospheric absorption was about ·9. Taking this value, the illumination given by the arc in "A" tower was about 13,180 candles.

Experiments were made on the evening of February 28th with the Mew Island lens 4 inches out of focus, and with the Mew Island lens in focus. Observations were also again made with the cylindrical lens with vertical prisms. At 8:30 p.m. the illumination with the vertical prisms was 1,573 candles at the focus, or ·0382 candle at hut 2 (1,483,000), which corresponds to ·4629 candle at hut 2 (17,790,000), with the Mew Island lens accurately in focus. This corresponds to an illumination of 10,100 candles in "A" tower. At 10:30 p.m. the haze had increased, and the observation with the vertical prisms gave an illumination of ·03137 candle at hut 2 (1,206,000). This corresponds to a source of light of 8,217 candles in "A" tower. From 10 to 10:30 p.m. an attempt was made to measure the illumination given by the Wigham gas 108-jet, and the six-wick oil, but the haze was too great to admit of any measurements being made. Hence there must have been a very considerable quantity of the light absorbed by the atmosphere.

The observations with the Mew Island lens, when the arc was 4 inches out of focus, gave an illumination of ·3753 candle at the focus of the lens in hut 2, or ·0092 candle at hut 2 without the achromatic lens (353,700). With the multiplying factor for the lens 4 inches, or 10cm. out of focus, this gives 4,844 candles as the illumination at "A" tower, and, allowing 1cm. more for one quarter of the breadth of the 40mm. carbon, this would give 5,860 candles as the illumination in "A" tower. A direct measurement with the Mew Island lens accurately in focus, when two machines were employed to give a single arc, gave an illumination of 16·58 candles with the lens at the focus in hut 2, *i.e.*, ·4066 at the distance of hut 2 (15,630,000), which corresponds to an illumination of 8,886 candles in "A" tower. Seeing that the haze was too great to admit of measurements being made with the 108-jet at hut 2, we should probably hardly be wrong in supposing that the illumination actually produced in the "A" tower was at least double the above values which have been derived from the observations in hut 2, making no allowance for the absorption of light by the atmosphere. This would give from about 10,000 to 12,000 candles for the light produced from one machine at an electro motive force of 48 volts and a current of 137 amperes, whilst two machines at an elecromotive force of 57 volts and a current of 180 amperes would give 17,770 candles

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Time.	E.M.F. in volts.	Current im amperes.	Illumination at Hut 2 with V.P.	Illumination at Hut 2 with M.I. lens.	Intensity of Source of Light in "A" tower.	Naked Light giving same Illumination.	Remarks.
8:45	—	—	—	·0009	—	34,590	108′.
9:0	62·2	167	·0406	·4872	10,640	18,730,000	Two machines parallel.
9:20	—	—	—	·00111	—	42,670	108′.
9:30	—	—	·0263	·3156	6,890	12,160,000	Two machines in series.
9:40	62·2	176	·0516	·6192	13,520	23,800,000	Two machines in series.
9:45	—	—	—	·00111	—	42,670	108′.
9:50	62·2	176	·0483	·5796	12,650	22,280,000	Two machines in series.
10:0	51·	131	·0263	·3156	6,890	12,160,000	One machine.
10:15	—	—	—	·00129	—	49,600	108′.

On March 6th and 7th measurements were made with the Mew Island lens with the arc accurately in focus, and also 2 inches out of focus.

On March 6th red and green glasses were used in measuring with the photometer, and on March 7th the same red and green glasses, and the blue solution of ammonia sulphate of copper which had been used in the photometric gallery were also used, and measurements were also made without these media. The measurements on March 6th, about 10:30 p.m., with the arc accurately in focus, gave 4,690 candles with red light, 10,600 candles with green light, and 8,236 candles with white light (1,210,000).

There was a considerable amount of haze, and the greater part of the evening was spent in various experiments in sky-flashing with the Wigham gas, and also with the electric light.

On March 7th the sky was remarkably clear; from hut 2 the French lights were brilliant, and even the Varne light could be clearly seen.

With the Mew Island lens and with the arc 2 inches out of focus but in the focal plane, at 9:15 p.m. the illumination was :—

·0635 candle at hut 2 by red light (2,441,000).
·1245 ,, ,, green ,, (4,785,000).
·2144 ,, ,, blue ,, (8,241,000).
·09654 ,, ,, white ,, (3,711,000).

These numbers correspond to—

8,150 candles by red light at "A" tower.
15,970 ,, green ,, ,,
27,520 ,, blue ,, ,,
12,390 ,, white ,, ,,

At 10 p.m observations with cylindrical lens and vertical prisms and arc in focus gave—

82,790 candles by red light at "A" tower.
13,730 ,, green ,, ,,
16,630 ,, blue ,, ,,
10,390 ,, white ,, ,,

At 10:15 p.m. observations with the Mew Island lens accurately set with the arc in the focus gave—

·4690 candle at hut 2, or 8,925 candles at "A" tower by red light (18,030,000).
·7044 candle at hut 2, or 15,380 candles at "A" tower by green light (27,080,000).
·6898 candle at hut 2, or 15,060 candles at "A" tower by blue light (26,530,000).
·5996 candle at hut 2, or 13,090 candles at "A" tower by white light (23,040,000).

The values given in the same way with two machines to one arc were:—

·3893 ... 8,500 ... red light (14,960,000).
·8636 ... 18,860 ... green ,, (33,200,000).
1·525 ... 33,300 ... blue ,, (58,610,000).
·9280 ... 20,260 ... white ,, (35,670,000),

no allowance being made for absorption by the atmosphere.

On the evening of April 9th some observations were made at hut 2 to determine the relative illuminating powers from a single arc when supplied from one machine, from two machines clutched together in series, and from two machines running together parallel for quantity.

The cylindrical lens with vertical prisms was used, and the illumination at hut 2 was ·0263 candle with one machine (1,011,000), which corresponds to 6,890 candles at "A" tower.

The illumination at hut 2 with two machines in series was ·0395 candle (1,518,000), corresponding to 10,360 candles at "A" tower, and with two machines parallel for quantity was ·0406 candle at hut 2 (1,561,000), or 10,640 candles at "A" tower, no allowance being made for absorption by the atmosphere.

The evening was fairly clear. At first the Calais light was not seen, but during the evening there was a slight improvement, and at the end the Calais light was just seen. The order of the observations and the current and electromotive force are given in the above table :—

At 9:30 p.m. the change was made in the connections between the two machines, but from the observations of E.M F. and current it would appear that probably the machines were not clutched together, and therefore they would alter their phase and so fall into step together; and so as regards the external circuit would still be working as two machines parallel.

In this table the intensity of the source of light is deduced from the illumination measured at hut 2, by means of the formulæ on pages 117 and 135, in which no allowance is made for the absorption by the atmosphere.

The values (given for comparison) of the single 108-jet or 108′ will show the change in the transparency of the atmosphere during the evening

Effect of Placing the Electric Arc out of the True Focus of the Lens.

On February 27th, when the arc was 8in. out of focus, observations were made as to the effect of raising the arc 1in. and 2in. above the focal plane, and of lowering it 1in. and 2in. below the focal plane.

In the first case the light was thrown down and illuminated the space extending from near the lighthouse quite to the horizon.

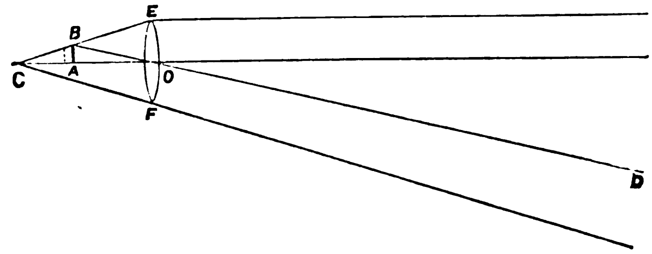

Fig. 6.

Let E O F represent the refracting portion of the lens.

Suppose it to subtend an angle of 30 deg. at C the principal focus. Let C O = 36in. Let C A = 8in., and A B = 2in. When the arc is at B, which will then be very nearly on the line C E, the rays proceeding from B to E will be refracted to the horizon. The axis of the beam will be in the direction B O D, inclined at an angle about 4 deg. below the horizon. At the distance of one mile from the lighthouse, the axis of the beam would be 380ft. below the focal plane.

The portion of the beam falling on the part of the lens near F will be refracted in a direction inclined at an angle of about 8 deg. below the horizon, and at the distance of half a mile will reach a point at a depth of 380ft. below the focal plane, *i.e.*, at the South Foreland the central refracted portion of the beam would illuminate the sea up to within half a mile of the lighthouse.

The intensity of the light in the direction of the axis of this beam, from a point 8in. out or focus, is about $\frac{1}{150}$th part of the intensity when the arc is placed accurately in the focus of the Mew Island lens, *i.e.*, not very far short of the intensity from the quadriform 108-jet gas, being about $3\frac{1}{2}$ times the intensity from the single 108 gas jet as mentioned on the same evening, when it gave an illumination of ·001443 candle at hut 2 (55,470)

The divergence from the refracting portion of the lens is about 8 deg., and the beam extends from the horizon, and will illuminate the sea up to within half a mile of the lighthouse.

The whole divergence of the reflected portion of the beam would be about 20 deg., and both on account of this great divergence, as well as on account of the diminution in the intensity of the beam, it is quite clear that it would never be advisable in practice to put the source of light so far as 8in. out of focus.

Let us consider the case when the arc at B is 4in. out of the focus of the lens, and raised 1in. above the focal plane.

C O = 36in., C A = 4in., A B = 1in. and O E about 10in

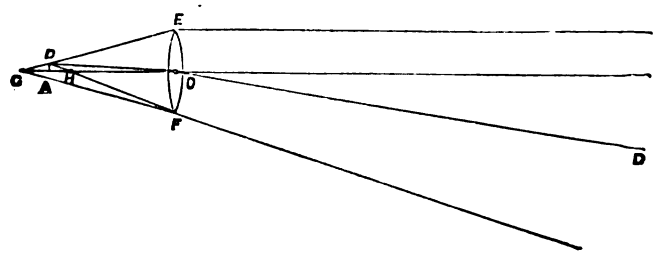

Fig. 7.

Under these circumstances the point B will be very nearly on the line C E, and the light proceeding from the arc at B to the portion of the lens near E, will be refracted to the horizon, whilst the axis of the beam will be inclined at an angle of about 2 deg. below the horizon, and at a distance of 2 miles from the lighthouse would be at a depth of 330ft. below the focal plane.

The divergence of the refracted portion of the beam will be about 4 deg. and the portion of the beam refracted near F will be 330ft. below the focal plane at a distance of 1 mile from the lighthouse.

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This arrangement will illuminate the surface of the sea from the horizon up to within 1 mile of the lighthouse, and the intensity of the light in the direction of the axis of the beam, striking the sea at a distance of 2 miles, will be about $\frac{1}{15}$th part of the full intensity of the electric beam through the Mew Island lens with the arc accurately in the focus, and will be about double the intensity of the quadriform 108-jet gas.

The whole divergence of the reflected portion of the beam would be about 10deg., and a portion of the light would be thrown down on the sea up to within half a mile of the lighthouse at the South Foreland.

Probably this divergence would be regarded as giving a longer period than necessary for the period of visibility of the beam when it is revolving, and it would not be advisable to diminish the intensity of the beam so much by putting the arc so much as 4 inches out of the focus of the lens.

Let us consider now the experiments of March 6th and 7th, when the arc was 2 inches out of focus in the focal plane, and also raised ½ inch above and lowered ½ below the focal plane.

When the arc is 2 inches out of focus and raised ½ inch above the focal plane, the upper part of the beam, as in the last case, will be refracted parallel to the horizontal plane, and will reach to the horizon (*see* Fig. 7), but the divergence will be only about 2deg. instead of 4deg.; hence, while the axis of the beam will be 330ft. below the focal plane at a distance of 4 miles from the lighthouse, the part of the beam refracted near F will be 330ft. below the focal plane at a distance of 2 miles from the lighthouse.

The intensity of the light in the direction of the axis of the beam, striking the sea at a distance of 4 miles, will be about $\frac{1}{13}$th of the full intensity of the electric beam through the Mew Island lens with the arc accurately in focus, *i.e.*, thus, at the South Foreland the Mew Island lens, with the arc 2 inches within its focus and raised half an inch, will give a beam whose axis strikes the sea at a distance of about 4 miles from the lighthouse, and whose intensity is equal to the full intensity of the electric arc when placed accurately in the focus of the cylindrical lens with vertical prisms.

This intensity is from six to seven times the full intensity of the *quadriform* 108-jet gas.

The full intensity of the electric beam through the Mew Island lens with the arc accurately in its focus being from 70 to 80 times the full intensity of the quadriform 108-jet gas through the same lens

The whole divergence of the reflected portion of the beam from the outer prisms would be about 5½deg., and a portion of the light would be thrown down upon the sea at the South Foreland up to within 1 mile of the lighthouse, the lower edge of the beam at the distance of 1 mile being at a depth of 350ft. below the focal plane. This arrangement of the Mew Island lens when revolving would give a duration of flash nearly equal to that from the "C" tower, where the six-wick oil light has a divergence of about 6½deg., and would illuminate the sea from a point 1 mile from the lighthouse up to the horizon, the strongest part of the beam meeting the sea level at a distance of about 4 miles from the lighthouse. The measurements of candle-power at hut 2, when the arc was above or below the focal plane, show that in the focal plane the intensity was about from two-thirds to three-fourths of the intensity at the same distance along the axis of the beam. Hence the illumination thrown on the sea increases on approaching the lighthouse, and at 2 miles is from two to three times the illumination thrown on the sea at the distance of 4 miles.

With a light so brilliant as the electric light it would seem advisable to make the diameter of the lantern 4 inches smaller, to place the arc in the centre, and to raise it about half an inch above the focal plane. This will produce a beam of about 5½deg divergence with the Mew Island lens, and will illuminate the sea from the horizon to within 1 mile of the lighthouse.

In this way the concentration and the want of steadiness of the electric light would be greatly remedied, so that in hazy weather it would be better seen by the mariner, and when revolving would no longer resemble a sudden brilliant flash, but rather a steady and intense light lasting long enough to give him his bearings. I would recommend this method of using the electric light in lighthouses, and believe that if it were so used it would be hailed with delight by the mariner.

If we apply the above formulæ to find the illumination from one 20-candle light placed in the focal plane in the axis of the lens, at distances of 1 cm., 3 cm., 5 cm., 7 cm., 9 cm., 11 c.m., and 13 cm. respectively, from the focus of the lens, the illumination at hut 2 with the Mew Island lens would amount to ·0001754, ·00002067, ·00000754, ·00000386, ·00000234, ·00000157, ·00000113 candle repectively.

Now, taking one in front of and another behind the focus at each distance, the whole illumination amounts to ·000425 candles, *i.e.*, about one-third of the actual illumination gained from the single 108-jet in actual experiments.

If we attempt to estimate what light reaches hut 2 or any one distant point from the Wigham gas burner, we must take only those burners which are near enough to the axis of the lens to be focussed near to the position of the disc in hut 2.

Hence there can hardly be more than one burner in front and one behind the focus in each ring which can illuminate the point. Also, of these, a considerable fraction of the light from the flames behind will be absorbed by those in front.

With 14 lights, one behind the other in a row, in the seven rings of the 108 gas jet, it would appear from the investigations on the transparency of flames that a very small proportion of the light from any except the five or six front lights will be allowed to pass through.

Another mode of Comparison of Sources of Light.

Another way of estimating what light the 108-jet will give at any distance would be to assume that from the large area of flame the light is uniformly distributed over a given area, and to measure the divergence of the beam.

Taking the horizontal divergence at 14¼deg., as measured by me on September 22, 1884, we get the light diverging from the source and falling upon the lens, which subtends 60deg. at the focus, concentrated into a conical beam with an angle of 14¼deg. at the vertex of the cone.

Hence, at a distance x from the source, the illumination will be

$$\frac{L}{x^2} \times \left(\frac{\tan 30^\circ}{\tan 7\frac{1}{8}^\circ}\right)^2.$$

Hence, at the distance of hut 2 the illumination would be ·0012 candles from a source of 2,160 candles behind the Mew Island lens.

Probably the illumination is not quite equally distributed over a given area, but would be somewhat brighter in the axis of the beam, so that at the distance of hut 2 in a clear atmosphere the illumination would be greater than the value here indicated.

On April 1st the quadriform 108-jet gas was measured by me in hut 2 without the achromatic lens, and gave an illumination of ·004995 candles (192,000), and the single 108-jet was measured by means of the lens in hut 2, and gave an illumination of ·001216 candles at the distance of hut 2 (46,740).

Observations with the triform six-wick oil light on the same evening (April 1st) gave the illumination from the six-wick triform oil as ·798 of the quadriform gas.

Hence the six-wick triform gave an illumination of ·003987, or very nearly ·004 candles (153,300).

The measurement of the Douglass 10-ring gas on the same evening, without using the achromatic lens, gave an illumination at hut 2 of ·00186 candles (71,500), *i.e.*, more than half as much again as the illumination from the 108-gas jet.

This method of estimating the intensity of illumination at any point is not applicable to the electric light, since the light from the arc or from any source of light of small diameter is not uniformly distributed over the illuminated area.

Experiment with Incandescent Lamps.

A Swan incandescent lamp of 100 candle-power, and also a 50-candle lamp of smaller size, were, each in turn, placed in the "A" tower in the focus of a Mew Island lens. The beam was turned on hut 2, and the measurements made of the illumination were compared with the illumination from the 108-jet gas in the "B" tower. The following results were obtained:—

Source of Light.	Illumination at Hut 2.	Naked light giving the same Illumination.
108-jet gas	·001423	54,700
100-candle glow lamp	·00084	32,300
50-candle glow lamp	·00099	38,000

The glowing fibre of the compact 50-candle lamp gave a stronger illumination than the larger 100-candle lamp, and more than two-thirds of the illumination from the 108-jet gas light behind the same lens.

This experiment suggests the interesting question whether the grouping of glow lamps within the compass of a sphere six inches in diameter will not give a very effective lighthouse light.

Sky Flashing with the Electric Light.

On the evening of March 6th, from 10:15 p.m., and again on the evening of March 7th, from 8:30 p.m. to 9:10 p.m., experiments were made with the Mew Island lens revolving in front of the electric arc, which was placed below the focal plane so as to throw the electric beam above the horizon, to illuminate the haze and floating clouds.

With the electric arc 2 inches and 3 inches below the focal plane, a brilliant cone of light passed over the heads of the observers at hut 2, which was apparently almost divided into two separate cones with their vertices opposite ways, the space within an angle of about 30deg. over the head of the observer being so transparent as to send very little light to the eye. In the distance, towards Ramsgate, the cone of light seemed to gather again and to dip towards the horizon, an effect due to the fact that the observer was looking nearly in the direction of the beam. On March 7th the light was thrown so as to describe a wider cone, by lowering the electric arc 6 inches below the focal plane. By this means the haze and clouds at a greater elevation were brilliantly illuminated.

The arc was also placed 2in. out of focus so as to give a divergent beam, and lowered 6in. below the focal plane, while the Mew Island lens was revolved in front of it. In this way a brilliant but very divergent beam was thrown into the atmosphere above the heads of the observers, showing to perfection any effect which may be produced by flashing lights on the sky. It is possible that it may be advantageous to the sailor on a fairly clear night to have the electric light illuminating the sky over his head instead of falling on his vessel, especially if he should be approaching the light. The diverging cone of the electric light when thrown upon the sky may be seen above their horizon by vessels far beyond the horizon of the lighthouse. If the arc be placed 3in. below the focal plane, the focal length of the lens being about 3ft., we see that at a distance of about 12 miles, the beam would be about 1 mile above the observer.

There does not seem to be any special advantage to be obtained by throwing the light up into the sky during a fog, for experiments on the penetration of a fog by light have shown that on approaching the electric light in a fog the observer first becomes conscious of the presence of a distinct source of light by observing a bright point, the electric arc itself, or, when a lens is used, the image of the electric arc formed by the lens.

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When the source of light is alternately eclipsed and exposed, then the observer becomes conscious of the existence of the source of light; but for a very considerable density of fog in which he is enveloped he cannot fix upon the direction of the source, the light coming to his eye being almost equally bright in all directions.

Experiments with Steam Fogs.

In experiments with steam in the photometric gallery the electric light and the 108-jet gas were tried, and were completely shut out by 30 or 40 feet of fog. As the fog cleared, and as both lights were alternately eclipsed and exposed, the observer, being near the outer limits of the fog, first became conscious of the light from the electric arc, and recognised it by its whiteness, after which a considerable interval elapsed before he recognised the yellow glare of the gaslight. Then, as the steam gradually cleared away, in the midst of the white electric glare, he caught the brilliant point of light of the electric arc, and after that he had to wait a considerable time longer before he was able to see any portion of the source of the 108-jet gaslight.

When first the faintest illumination from the electric light became visible, the illumination was not red or yellow, but white, and at any and all distances there could be no question whatever as to the source which was giving the light. The illumination of the fog was of the same colour as the source of light, showing that with a mixture of air and steam, forming a cloud, rays of different colours were absorbed and scattered very nearly in the same proportions. This shows that the proportion of the electric light which is scattered by such a fog is no greater than the proportion from any other source of light, and that we may make use of the same coefficient of transparency for the different lights.

A Wigham 108-jet gas burner, giving an illumination of about 2,500 candles, and a De Meritens arc lamp, giving about 12,000 candles, were placed at one end of the gallery. When the daylight was shut out and the fog admitted, I could see no light at all at any distance beyond 100ft. From 90ft. to 100ft., when the electric light was exposed, there was just the faintest possible illumination of the fog, but when the gas was exposed and the electric light eclipsed not the slightest illumination could be seen, until a point 65ft. from the source of light was reached. On approaching nearer, at 50ft., the glowing 44mm. carbons became visible, and at 36ft. the whole breath of the gas flames came into view at once.

The electric light of 12,000 candles, the Wigham 108-jet gas of 2,500 candles, a single burner of 20 candles, and the Douglass one-candle standard were observed in the same steam fog with the following results:—

The glowing carbons were seen to a distance of 117ft., the 108-jet gas was seen to a distance of 80ft., the single gas jet was seen to a distance of 70ft., and the standard candle was seen to a distance of 55ft.

These results show that the distance to which a light is seen in fog depends on the intrinsic brightness of the flame, and that an increase in the size adds very little to the penetrative power.

LAUNCH OF A TELEGRAPH CABLE STEAMER.

Messrs. R. Napier and Sons launched, on Monday last, from their shipbuilding yard at Govan a twin-screw cable steamer for the Eastern Telegraph Company, London, specially designed by Mr. Joseph Birnie for laying and repairing the company's submarine cables. The vessel is built of steel to class 100A at Lloyds's, and is of the following dimensions:—Length, 250ft.; breadth, 34ft.; depth, 25·4ft.; with a gross tonnage of about 1,500 tons. Externally the steamer with her cutwater stem has a very handsome appearance, while internally the arrangements are of the most complete character to suit the peculiar service for which she is intended. Besides having the usual appliances of a first-class merchant steamer, the vessel is fitted with special tanks for holding cables, and has been subdivided into 27 water-tight compartments for trimming and ballasting purposes. The cable gear is of the most modern design, and is driven by a pair of powerful engines. It consists of bow guards and triple sheaves, with leads for paying out and taking in cables, dynamo meters for registering the pressure, steam sounding machines, &c. The bow sheaves over which the cables are passed give the vessel a peculiar appearance, but they have been wrought in by the builders in an ingenious manner to form part of a clipper bow, which adds to the symmetry of the steamer. Very complete accommodation has been provided for the officers and electricians, and as the vessel is intended for service in hot climates Messrs. M'Whirter and Roberts' steam ventilating apparatus has been fitted throughout the ship, which will also be lit by a very complete system of electric light. Two sets of compound surface condensing engines have been constructed at the builders' Lancefield Works, under the supervision of Mr. A. Beldane, the company's superintending engineer.

After the launch the company adjourned to the model room, where lunch was served. Amongst those present were:—Messrs. A. C. Kirk, John Hamilton, and James Hamilton, of the builder's firm; Sir James Anderson and Mr. John D. Pender, directors of the Eastern Telegraph Company; Sir William Thomson and Lady Thomson, Mr. Joseph Birnie, who designed the ship; Mr. Renwick, the company's representative in Glasgow, and Mrs. Renwick; Principal Jamieson, Mr. M'Whirter, London; Mr. George Agnew, Superintendent Hamilton, &c. Mr. A. C. Kirk, who presided, gave the toast of "The 'Mirror' and the Eastern Telegraph Company." He remarked that, although the "Mirror" was a reflection of all the perfections of telegraph ships, she had not been called the "Mirror" for that reason. Her name was called "Mirror" in honour of Sir William Thomson's great scientific discovery. Sir James Anderson, with whose name the toast was coupled, replied. He passed a eulogium on Sir William Thomson for the skill he had displayed in the science appertaining to electricity. They were now able to telegraph to Egypt in ten minutes, to America in four minutes, and he did not think this could be beat. They had also telegraphed to India, and received a reply in five minutes. The "Mirror," he said in conclusion, had been in all her arrangements entrusted to Mr. Kirk, and he had no doubt she would reflect the great skill of that gentleman and the ability of her builders, one of the greatest firms in the country, and would also do credit to Sir Wm. Thomson's gaeat invention. Sir Wm. Thomson, after acknowledging the kind words spoken of him, proposed in complimentary terms "The Builders." Mr. James Hamilton replied, remarking that it was the fourth telegraph vessel built by them, and they now knew the requirements of the telegraph companies, and were quite prepared to equip telegraph ships from keel to truck. Sir James Anderson proposed the "Health of the Chairman of the Telegraph Company, Mr. Pender." Mr. E. D. Pender, in his father's absence, acknowledged the toost, and in graceful terms proposed the "Health" of the lady who named the vessel, Lady Thomson. Sir William Thomson responded, and the proceedings shortly afterwards terminated.

COMPANIES' MEETINGS.

Mediterranean Extension Telegraph Company (Limited).

A general meeting of the shareholders of this Company was held at the Cannon-street Hotel, on the 21st inst., for the purpose of receiving an account from the liquidators showing the manner in which the liquidation proceedings have been conducted and the property of the Company disposed of; and for fixing the liquidators' remuneration.

The Hon. Ashley Ponsonby (the joint liquidator with Mr. John G. Griffiths) presided, and having read the notice convening the meeting, said: You have all, I suppose, had a copy of the accounts placed in your hands, and we shall be very happy to give you any explanation you may wish on those accounts. You will observe that there is an item of £330. 0s. 3d. unclaimed dividends. That in the ordinary course of events would be an asset, but under existing circumstances we shall have to ask the intention of the Court as to what we may do with it. Every effort has been made to find out those to whom it belongs, but up to the present moment we have been unable to get any information whatever. Therefore, as to that £330, we shall have to ask the intention of the Court. You find that we have a balance to deal with of £1,739. 15s. 9d. Out of that amount it is proposed to return you another 1s. 2d. per share. That will absorb £886. 13s. 4d., and it is proposed to give that balance to the liquidators. It has always been the wish that some remuneration should be given to the old officers of the Company. Unfortunately, as you are aware, poor Mr. Tombs died shortly after the liquidation began, and he has therefore ceased to be a claimant in any way; but there are two other officers to whom, I think, the remarks of Sir James Carmichael apply. At one of the meetings Sir James, in reply to a shareholder, stated that if the officials, Mr. de Normann, Mr. Tombs, and Mr. Atmore were thrown out of employment, they ought to be remunerated. Well, we have taken counsel's opinion on the question, and we find we are unable to do that in the ordinary way; but you have the power of conferring on the liquidators' a sum for their remuneration, and out of it, if you pass the resolution that will be proposed, we intend to give Mr. de Normann £250, and Mr. Atmore £100, making together £350. That is the suggestion which we are going to make; and I feel the less hesitation in doing it, as you may all be aware of the long service which Mr. de Normann gave to the Company since its commencement, and from the fact that he is in old age and failing health. With reference to Mr. Atmore, he has given us great assistance, and I feel that £100 is the minimum that we can offer him. That will absorb the whole of our assets, with the liquidators' remuneration. We have now been over two years in liquidation, and we feel that we are not asking too much. It may be asked of us, Why have you been two years, as that seems a long time? In the first instance, almost immediately after the resolution to wind up this Company was arrived at the Italian Government gave us notice that we had no powers to sell the concessions, but that they would assist us in doing so. From that time forward till a whole year had passed negotiations were going on in Italy, and the Italian Government introduced a Bill into their Houses of Parliament, which was passed, authorising us to make over the cables and concession to the Eastern Company. That took rather more than a year. We next received notice of the action that was about to be commenced—of which I wish to say a few words—between the preference and the ordinary shareholders. That action was commenced, and the last part we had to do with it was in regard to the taxed costs, which were not delivered till last August. You may suppose that, although we had nothing directly to do with that action, we had a considerable amount of work in connection with it, as they were sending for our books, and looking into our accounts, and wishing for information. All this gave us no little anxiety, although we ourselves were no parties in any way to the action, which, as you are aware, was decided by the Courts in favour of the ordinary shareholders. All that your liquidators had to do was to pay the bills, which were very excessive, and we were very sorry we had to pay them. That was not done till last August; and we had to give you a whole month's notice in the *Gazette*. We are now met to-day to give you a statement of accounts. This is, I think, as clearly as I can state, the whole work of the liquidators. Is there any other point you would like me to go into? Mr. Griffiths will answer you on any point connected with the figures. I would only add that, although there has been this delay, you were not

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kept out of your money, and we have paid you up to the present time £3. 5s. a share, and now we propose, as I have said, to give you another 1s. 2d.

Mr. WELLS said he thought, after the speech of the Chairman, that the shareholders ought to be very much obliged to the gentlemen who had acted as liquidators. For his own part he was very agreeably surprised at the amount already returned, and he was very pleased that there was a chance of their getting an additional 1s. 2d. a share. He had much pleasure in proposing the following resolution :—"Resolved, that the audited accounts, showing the manner in which the liquidation proceedings have been conducted and the property of the Company disposed of, be and are hereby adopted and approved."

Mr. CLOUT seconded the motion, which was carried unanimously.

Mr. NORRIS then moved the following resolution :—"Resolved, that it be recommended to the liquidators to declare a final dividend of 1s. 2d. per share on the preference and ordinary shares of the Company."

Mr. WHITTAKER seconded the resolution, which was also carried unanimously.

Mr. THOMAS ADAMS said that as the officials had been deprived of what they had a reasonable right to expect—a long continuance of their services—he thought the proposal to give them some compensation was only a right one. He also thought that the liquidators should be remunerated for what they had done in winding up the concern in such a very short time compared with some other cases. He concluded by moving the following resolution :—"Resolved, that the remuneration to the Hon. Ashley G. S. Ponsonby and J. G. Griffiths, Esq., the liquidators of the Company, be fixed at the sum of £853. 2s. 5d., the liquidators undertaking to pay and satisfy any outstanding claims on the part of the late officials of the Company." He did not know whether the claims of the officials were considered legal ; but the shareholders took it that the liquidators regarded them as moral claims.

Mr. GRIFFITHS : It is not a claim that we could at once admit as legal; but a legal claim might be made, and that might keep the liquidation open for a long time.

Mr. LEAN seconded the motion, which was carried unanimously.

The CHAIRMAN having intimated that that closed the business,

Mr. GRIFFITHS stated that there would be one more meeting, so as finally to wind up the Company, but there would be nothing to do. It would not be held till the liquidators got the direction of the Court as to the unclaimed dividends.

A SHAREHOLDER : Will you pay the 1s. 2d. a share before then ?

Mr. GRIFFITHS : We shall pay that now, directly, but we shall have to come before the shareholders with our final accounts when we get the direction of the Court as to the unclaimed dividends of £330.

A SHAREHOLDER inquired whether they could not pass a resolution to the effect that unless that amount were claimed within a certain period it would be divided among the shareholders who had come forward ?

The SOLICITOR (Mr. Campbell) said he feared that when once the money got into the Court of Chancery it would be a long time before they let it out again, unless the shareholders showed they had a right to it.

Mr. WELLS said that they had a right to it under the Articles of Association.

The SOLICITOR : Yes, but the Company is in liquidation. If it was not for the holding of these funds by the Government and others we should not hear of the large windfalls we do.

The CHAIRMAN : I am afraid this will not be a large windfall ; but still it would be 6d. a share.

The SOLICITOR : No doubt Mr. Wells is correct that we have a right to this by the clause (which he read) in the Articles of Association. As a going concern we could say to the Court that we had a right to divide this amount if the parties do not come forward and claim their dividends within three years.

Mr. WELLS : You will do the best you can for us in the matter ?

The SOLICITOR : Yes, certainly. I think if it is not claimed within three years it ought to be divided among those who do come forward.

Mr. WELLS proposed a vote of thanks to the Liquidators, who, he thought, had put down a very small amount for their remuneration. He thought the result of the liquidation must be considered very gratifying.

The SOLICITOR also thought it was very satisfactory, remembering that when the liquidation commenced the opinion of the public was that the value of the shares was about £2, whereas £3. 6s. would be returned.

A SHAREHOLDER having seconded the motion, it was carried unanimously.

The CHAIRMAN returned thanks, and the meeting then separated.

LEGAL.

Electric Lighting at Witney.

In the Queen's Bench Division of the High Court of Justice, on Monday, before Mr. Justice Field, judgment was given in the action of the Provincial Brush and Electric Light and Power Company *v.* Shillingford and Bateman, which was tried a fortnight before. The learned Judge said this was a claim for £53. 17s. 2d., the balance of an account for an installation of the electric light at the defendants' brewery at Witney, in Oxfordshire. The defence was that the installation was "not a success." The original claim was for £153, and the defendants, having paid £100, claimed to have that amount returned, as having been paid by mistake. The Judge explained how the electric light was produced. The motive power in this instance was furnished by a 3½ horse-power steam engine belonging to the defendants, with which the plaintiffs had nothing to do. That engine actuated the dynamo, which deposited its electric force into the commutator, which took it in the shape of a current and carried it first to the accumulator, where it was stored to be available when the engine was not at work, and thence it passed to the lamps. The contract was somewhat uncertain with regard to the number of lamps ; it was intended originally to be 15, whereas 20 or 21 were actually placed, the plaintiffs remarking that if the larger number of lights was provided they must not be all run at the same time. The estimate was dated July 15th. The defendants asked for a guarantee that the installation should be a success, and the plaintiffs expressed their willingness to give such a guarantee if the installation was carried out under their personal superintendence. Accordingly, written instructions were given to the defendants' engine driver as to how to work the engine with a view to the adequacy of light ; and it might be a question whether, for such delicate operations, a man was not required who was of a superior education to an ordinary engine driver. This man was instructed how to work the engine, and was told it must be so worked that the electric current had a volume of 25 amperes ; also that the battery must not be charged while the lamps were alight. The installation was made complete on September 10th, but very soon complaints were made that the light was not satisfactory. The plaintiffs went down and found that the brushes had given way, although a brush ought to last three or four months. The plaintiffs replaced the brushes, made other repairs, and complained that the engine was running while the lights were burning. The defendants subsequently paid £100 on account of the cost of the installation, and promised to call, but did not do so. Then the dispute arose which resulted in this action. The installation was not a success, because the defendants had to use gas ; but the question for decision was to what this want of success was due. Was it a defect of installation, in which case the plaintiffs were responsible, or was it a consequence of the mode of running the machinery, for which the defendants were responsible ? He had asked himself, as a medical man would in a case of illness, what were the symptoms in this case ? They were the destruction of the fuses, the breaking of the filaments, the blackening of the lamps, all of which were consistent with the same cause, namely too much energy, too much current, arising from there having been an overrunning of the engine. There was no mechanical defect imputed to the machinery ; and although no doubt the defendants had the greatest desire to do what they ought for the proper working of the installation, he believed that they did really and truly charge too heavily. Without pledging himself to perfect accuracy in his description of these scientific matters, he said without hesitation that the want of success in this instance was due to some other cause than a defect in the installation. There must therefore be judgment for the plaintiff company both on the claim and the counter-claim.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Dec. 22.		Business Done Week Ending Dec. 22. Highest.	Lowest.
Anglo-American	32,	33	32¼	31½
Do. Preferred	53½,	54½	54¼	54
Do. Deferred	10,	11	10½	10¼
Brazilian Submarine	10¾,	11	11	10¾
Cuba	11,	11½	—	—
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9¼,	9½	9¾	9½
Eastern Telegraph	11⅝,	11⅞	11 15-16	11¾
Do. 6 per Cent. Preference	13½,	14	13 13-16	13 11-16
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12¾,	13	12 15-16	12¾
German Union	9½,	10	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 1-16	6⅞
Do. Preference	13¾,	13⅞	13⅝	13¾
Great Northern	14¾,	15	14 13-16	14¾
Indo-European	32,	33	—	—
Reuter's	7,	7½	—	—
Submarine	200,	210	—	—
West India and Panama	⅝,	⅞	¾	—
Do. 1st Preference	8,	8½	8 7-16	—
Western Brazilian	6¼,	6½	6¾	6 5-16
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅞,	1	15-16	—
Oriental	3-16,	5-16	¼	—
United Telephone	12¼,	12¾	12 9-16	12¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3¼,	3¾	3¾	3½
Do (fully paid)	5¼,	5¾	5½	5½
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1½,	1¾	1 5-16	1⅛
Maxim-Weston	5-16,	7-16	⅜	—

MISCELLANEOUS.

Telegraph Construction	36,	37	37	36½
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24⅞	24½

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NOTES.

Burmah.—It is announced that telegraphic communication with Shwegyin has been restored.

Appointment.—M. Angel Mansi has been appointed the Spanish Director-General of Posts and Telegraphs.

The Brazilian Submarine Telegraph Company.—The traffic returns of this company for the week ended 25th December amounted to £2,605.

Cable Work in Italy.—We have received from M. Salvatore Raineri a pamphlet, with full description of the projected cables between Naples and Palermo.

Personal.—M. Fontaine has been made Judge of the Tribunal de Commerce de la Seine.—Mr. Jas. Swinburne has joined the staff of Messrs. R. E. Crompton and Co.

Electricity and Mining. — Electrical transmission of power has been resorted to during the current year in several mines of the Continent, and in each case with satisfactory results.

The Telegraph Battalion.—The section of the Telegraph Battalion of the Royal Engineers from the Cape will be quartered at Aldershot, instead of at Chatham, as previously ordered.

Geographical.—Our esteemed contemporary, *Electricité*, speaking of the Australian telegraphs, says that telegraphic communication between "Adelaide and Pesth" was established in 1877 !

The Crystal Palace.—We learn that the illumination of the Palace by the tens of thousands of tastefully arranged lamps, and by electric light, which has been so attractive a feature of the autumn months, will be extended and continued nightly.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 25th December were £2,052, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

A New Light.—Advices from Vienna state that experiments are being made, at Professor Lieben's chemical laboratory, with a new gas light invented by Dr. Auer. A cotton wick, saturated with an incombustible metal solution, is introduced into the flame of an ordinary Bunsen lamp, the result being a light similar to the incandescent electric light.

Another Electric Railway.—It is announced that the Swiss Government have granted a concession to a firm of electrical engineers at Geneva for the construction of a railway up Mont Salève, near Geneva. The line will be laid with a central rack, like that of the Righi railway ; but the toothed pinion of the engine which gears into it will be driven by electricity instead of by steam.

The Eastern and South African Telegraph Company.—This company announces that the coupons due on 1st instant on their Five per Cent. Mortgage Debentures will be paid on and after that date on presentation of the same at the banking house of Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C. Coupons must be left three clear days for examination.

Windsor.—At Windsor the erection of a new post office has been commenced by Her Majesty's Office of Works at the corner of St. Alban's-street, in the vicinity of the Royal Mews. The building will be of handsome Elizabethan design, with red brick facings and white stone dressings, and will contain commodious money-order and telegraph offices and sorting rooms with yard for the reception of the mail carts.

Too Patent.—A Washington stove dealer, it is said, invented a house telephone, a simple little contrivance, making use of gas and water pipes instead of wires, attached to which in each room was a transmitter and receiver. But he was informed that his machine was an infringement of the Bell, though he used no electrical current, and he has abandoned his intention of making a business of furnishing these instruments in houses.

H.M.S. "Pylades."—An important addition has been made to the active list of the Royal Navy by the completion for sea at Sheerness Dockyard of the new unarmoured composite corvette "Pylades," which was launched from the building slip on the 25th November, 1884. In addition to her other armament, the "Pylades" is also equipped with Gardner and Nordenfelt machine guns, and the electrical apparatus for discharging the spar torpedo.

Photographs of Lightning.—At the meeting of the Franklin Institute last month, Prof. Houston presented two photographs taken on a dark night by the light produced by flashes of lightning, in which a building and trees were distinctly shown. They were thrown on the screen by the aid of Prof. Holman's lantern miscroscope. The duration of the flash by which the plates were secured was estimated at the one three hundreth part of a second.

The Soudan Telegraphists.—At Aldershot, on Saturday, Colonel Mainguy presented a number of officers and men of the Royal Engineers on Church parade with medals and clasps for the late campaign in the Soudan. Some of the recipients had formed part of the Nile Expeditionary force, and others were employed between Suakim and Korti. The Colonel spoke in complimentary terms of the excellent work performed by the Telegraph Section.

Honours.—The Queen, it is announced, has been pleased to confer the honour of Knight Commander of St. Michael and St. George on Colonel Bateman-Champain, well known in connection with Anglo-Indian telegraph enterprise. It is also announced that George Edward Paget, Esq., M.D., F.R.S., Regius Professor of Physic in the University of Cambridge, has been appointed to be an Ordinary Member of the Civil Division of the Second Class, or Knights Commanders of the Most Honourable Order of the Bath.

Interruption to Telegraphic Communication. — A singular accident occurred at Newbury on Saturday afternoon, resulting in the interruption of telegraphic communication between the metropolis and Bristol and other places in the West of England. A large walnut tree was being removed by a traction engine from one part of Newbury to another, and when passing through Northbrook-street the branches caught the line of wires which cross that thoroughfare and snapped them. The damage will be repaired with as little delay as possible.

Transmission of Power.—In a short article relating to the electrical transmission of power, M. Hospitalier comes to the conclusion that to M. Marcel Deprez must be given the honour of being the pioneer in the application of electricity for this purpose. We are under the impression that neither the idea nor the actual testing of the idea is as recent as the Vienna Exhibition of 1875. Speaking for the moment from recollection, we are under the impression that a number of patents between the years 1840 and 1860 deal with the utilisation of electricity for the transmission of power.

The Electric Lighting Act.—Referring to the compulsory purchase clause of the Electric Lighting Act, the *Building and*

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Engineering Times says:—"The question raised seems to be whether the period of twenty-one years is sufficiently long or not; for that Parliament will refrain from imposing any limit at all is not to be expected. That the period at present specified is insufficient to encourage the development of electric lighting upon any extensive scale is, we think, sufficiently evident from the tardy progress it has made in this country as compared with what has been done on the Continent and in America.

MUST PAY.—An American contemporary says a new device has been invented for telephone stations. It is so constructed that a person wishing to use it enters a box, and on depositing a nickel in the fare box a clock indexes his entrance, and he is permitted to occupy the box five minutes. At the expiration of that time he must leave the box, or, if he remains, he must pay a second fare. Should he decline paying the fare he is bolted within, and the machine telephones the fact to the central office. Then he must remain until released by a messenger from said office. These boxes are designed for cigar shops, drug stores, and such places accessible to the public.

THE EDISON PATENT IN CANADA.—The taking of evidence before the Deputy Minister of Agriculture, on the application of the Telephone Manufacturing Company of Toronto, has been concluded and decision reserved. The application is to have the Edison telephone patent, now held by the Bell Telephone Company, declared void because of the importation, non-manufacture, and refusal to sell by the Bell Company. The Bell patent proper was annulled last year, but the Edison patent still holds good, and, as the Bell Company has brought an action against the Telephone Manufacturing Company for an infringement of the last-named patent, this application is made to set it aside.

A NEW METHOD OF PROPULSION.—The idea of propelling ships by forcing water out of pipes sternward has, as is well known, been put in practical application. An analogous method, which consists in forcing gases against the water, and thus establishing a means of propulsion, has been devised in Brooklyn, U.S.A. The system will, we are advised, soon be given a practical trial, the ship with which it is to be made having recently been launched. The method employed, briefly stated, consists in compressing a small quantity of air, which is then impregnated with petroleum spray. This is then exploded by an electric spark, and the large volume of gas generated is forced out at the stern.

THE NATIONAL TELEPHONE COMPANY.—From the December list of subscribers of this company in the Edinburgh district, we learn that each subscriber to the exchange system has a wire, bearing a number, running from his own office or residence to the company's nearest exchange or operating room. These exchanges, of which there are now four in full working order throughout Edinburgh and Leith, are connected together by cables, or trunk lines, and each exchange is provided with a switching apparatus, by means of which the operators in attendance can connect any two wires with each other, answer calls, and ring up subscribers. The exchanges are open day and night, and on Sundays.

ELECTRIC RESISTANCE OF ALCOHOL.—At the meeting of the French Physical Society, on December 4, M. Fousserau read a paper upon the Electric Resistance of Alcohol. His measurements have been obtained by Lippmann's method, and the arrangement was similar to that adopted in his experiments upon distilled water, &c. The resistance of commercial alcohol at 15°C. was found to be between 2·47 and 3·38 meghoms. Experiments were also carried out upon a mixture of alcohol and water. The resistance of these mixtures was generally found to be between that of alcohol and that of water, the minimum resistance being, for the mixture, three of water and one hundred of alcohol. M. Fousserau found that it was necessary to vary considerably the proportion of water in order to obtain an appreciable change in the resistance of the mixture.

PROPOSED TELEPHONIC EXCHANGE AT STIRLING.—A meeting of gentlemen interested in a proposal to institute a telephonic exchange in Stirling was held recently in the Golden Lion Hotel. Mr. A. R. Bennett, General Manager of the National Telephone Company, addressed the meeting on the utility of the telephone as a business adjunct, and explained that the proposed exchange would afford communication in the meantime with the subscribers within a six miles' radius from Stirling, the intention being afterwards to extend the communication to Glasgow, Dundee, Perth, &c. Mr. Mitchell Thomson, Edinburgh, a Director of the Company, also addressed the meeting. At the close a number of questions were put and satisfactorily answered by Mr. Bennett. On the motion of the chairman, votes of thanks were awarded to Messrs. Bennett and Thomson. A considerable number of gentlemen signified their willingness to join the exchange.

THE ELECTRIC LIGHT AND GAS COMPANIES.—Our readers are aware, says a contemporary, that the Imperial Continental Gas Association have undertaken the supply of electricity in Vienna. Another instance of an electric light installation being undertaken by a gas company is that of the Anglo-Romano Company, who are establishing electric lighting plant for illuminating several public and private buildings in Rome with a total of 12,000 incandescent lamps, 1,500 of which are expected to be in working order by May next. For the purposes of this installation, two self-exciting alternate-current dynamos, each to yield a current of 35 to 38 amperes, at a potential of 1,800 volts, are being prepared, one of which will serve as a spare machine. These dynamos will be driven by steam engines mounted on a common shaft with the respective dynamos. The electric lighting plant will be erected in the company's works, and the current will be conveyed to a maximum distance of about two miles.

THE ELECTRIC LIGHT IN KIMBERLEY, SOUTH AFRICA.—The illumination of the Kimberley Gardens and promenade concert which took place recently was the final item on the list or programme of festivities in connection with the opening of the railway to Kimberley. The arrangements for lighting the grounds by electricity were perfect, and reflected the highest credit on the energy of the borough electrician, Mr. R. L. Cousens. One lamp was erected near the cricket club's pavilion, and six more were fixed up under the trees and in the centre of the grounds. The electricity was generated by means of the spare machine taken from the Electric Light Works at the Compound to the workshops of the United Diamond Mining Company, where it was driven by that company's engine. The engine was a 25-lighter, fitted with an automatic regulator. The shifting of the wires, lamps, and supports had all been performed within four days, and at the same time the lights in the town, to the number of 46, had to be kept burning.

LIGHTING AT THE NEW THEATRE, BRUSSELS.—The Theâtre de la Bourse was opened on Thursday, 30th December, by an entertainment, the gross receipts of which were given to the poor of Brussels and the adjoining parish of Molenbeek-Saint-Jean. The lustres are designed by the architect, M. Chambon, to suggest the jewels hung from the roof of an Indian temple. They have also been arranged for

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gas or electric light at pleasure, so that, if so desired, the two illuminants may be used alternately. It was intended that the lighting should be by electricity; and M. J. De Luyck, who is both builder and proprietor, had agreed with one of the Brussels companies for the entire lighting, at a cost of 800,000 fr., or £8,000, when the negotiations fell through on his requiring a guarantee of non-extinction, which the electrical company was unwilling to accord. To lend additional *éclat* to the ballet of "Nina," which, by the way, is a London production, M. Emile Closset, constructor of the Melsens lightning conductors, has provided six 500-candle arc lamps, of which two are Foucault regulators and the rest hand-worked, fed by 360 Bunsen batteries of 60 couples each.

Circular Electric Bells.—The Kinetic Engineering Company are manufacturing a circular electric bell which has some commendable features. The electro-magnet and armature are of carefully annealed soft Swedish charcoal iron, and wound with the best silk-covered copper wire, having a conductivity of 98 per cent., and the whole apparatus is both well made and cheap. The hammer spring is of such form and so arranged with regard to the armature that, when the latter is attracted to the electro-magnet poles, the elasticity of the spring carries the hammer on to the gong, so that the latter is always struck, and with proper force, even though, through accident or otherwise, its position may have considerably altered. It is believed that this is the only circular bell in the market in which even the slightest shifting of the gong does not necessitate re-adjustment and regulation. A screw and slot arrangement at the back of the case enables a rough adjustment to be effected once for all when the bell is first put up, and no delicate adjustment or regulation is afterwards required, even although the bell be subjected to very rough usage. The general appearance is graceful, and readily lends itself to artistic decoration.

The National Telephone Company.—The directors and staff of the Yorkshire District of the National Telephone Company gave a ball on Monday evening, the 21st inst., to the lady operators and other friends at the Technical College, Bradford. Amongst those present were Mr. G. A. Steinthal and Major W. H. Shepherd (Directors), Major A. W. Jassen, Mr. and Mrs. A. Philipp and Mr. C. Philipp, Mr. J. C. Chambers (General Manager of the Company) and Mrs. Chambers, Mr. and Mrs. Michael Mullen, Mr. and Mrs. Walter Emmott (Halifax), Mrs. Frank Lumley, Mrs. W. J. Gray (Dewsbury), and Miss Marion Whitehead (Manchester). The following gentlemen acted as stewards:—Mr. J. Lumley, manager of the company's Bradford District; Mr. Ralph Mewburn, manager Leeds District; Mr. W. J. Gray, manager Dewsbury District; Mr. C. Ball, cashier; and Messrs. W. J. Davison, and J. Holroyd, inspectors. The reception room, ball room, and galleries were tastefully decorated with evergreens and drapery, whilst the band was screened from the ball room by a beautiful arrangement of foliage plants. Dancing commenced at nine o'clock and was continued until twelve o'clock, when a supper, provided by the Bradford Café, was served. After supper several ladies and gentlemen went through a programme of songs and recitations, which were much appreciated. After this dancing was resumed, and continued until after three in the morning.—Mr. Michael Mullen, shortly before the conclusion of a very enjoyable night, proposed a vote of thanks to the committee and to the givers of the ball for the entertainment so splendidly provided, a motion which was seconded by Mr. H. Storey, and carried unanimously.—Mr. Lumley, who responded in the absence of Mr. Chambers, said that he trusted this was the first of a series of such annual assemblies.—The music was provided by Mr. Stocks Hammond's band.

Electric Lighting at Leeds.—The Electric Lighting Committee of the Leeds Corporation have decided to illuminate the Victoria Hall by means of arc lamps, at a cost of about £450. Secondary batteries, by the Electric Power Storage Company, are to be provided, and these will be charged by dynamos which the Corporation already have in its possession in the basement of the Municipal buildings. The current is to be carried from the Corporation Offices to the Town Hall along a subway now existing in Calverley-street, and thence into the "false" roof of the Victoria Hall, from which will be suspended eight arc lamps with ornamental pendants. A small sub-committee visited Manchester to see several lamps tried, and they made selection of what is known as the Brockie-Pell, which is said to burn very steadily. Each of the eight lamps will be of 2,000 candle-power. As the electroliers, by means of which the Victoria Hall was lighted by Messrs. Crompton and Co. on the occasion of the last musical festival have not been removed, only a portion of the new arc lamps will be fixed to begin with. It is intended at the outset to hang two of the arc lamps in the middle of the hall, early in January, and before the scheme is completed the committee, and, possibly, the public, will be afforded an opportunity of witnessing the effect produced. The pair of 12 horse-power (nominal) Otto gas engines, by Crossley Brothers, which supply the dynamo power for illuminating the Municipal Offices are at present standing idle all day, so that by the making of a battery installation for the Victoria Hall the corporation will not require any additional engine power, but will be able to fully utilise that which they already have, without extra outlay upon machinery. The two engines are coupled, so that should one dynamo break down, the whole of the power can be run upon the other dynamo, the loss being thus nearly all compensated for. The preparations for putting the committee's project into execution, which are being carried out under the superintendence of the borough engineer's department, are approaching completion, and when the lamps come to hand they will be put in position and set going without delay.

The Stock Exchange.—From time to time we have noticed the proceedings of the Stock Exchange in connection with the Exchange Telegraph Company's work, and we now reproduce the following letter which appeared in the *Times* of Thursday over the signature "F.":—"Sir: The electrical transmission of Stock Exchange prices by means of the Exchange Telegraph Company's recording instruments is a public convenience so well established and so widely recognised that any interference with the 'tape' on the part of the Stock Exchange requires explanation. Permit me, then, to say something as to the motives and intentions of those members of the Stock Exchange who are petitioning the committee in the memorial, the text of which I enclose. In the opinion of the signatories 'outside' agencies for dealing in stocks and shares are no less injurious to the public than to the Stock Exchange, and they consider. therefore, that the Stock Exchange would only be discharging its obvious duty if, in the exercise of its undoubted right, it took steps to discourage them. The Stock Exchange is, and ought to be, not a close, but a regulated corporation, and the public will approve its action in refusing to extend its market to those who are not bound by its rules and regulations. It is to the instantaneous communication of Stock Exchange prices to persons who deal on the strength of them without being amenable to proper control that the development of

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'outside' business in its most mischievous form is directly due. Without the transmission of instantaneous prices the market must remain with the Stock Exchange, and the 'bucket shop' must cease to exist. The Stock Exchange does not object to the 'tape.' It has everything to gain and nothing to lose from publicity, which brings business by inspiring confidence. Not can it have any possible objection to the public getting its prices so long as it gets the custom which such prices induce. But while the 'tape' is thus desirable for the Stock Exchange. the Stock Exchange is indispensable to the 'tape.' Note well that what the Exchange Telegraph Company wants is the instantaneous price, and it is precisely this which the Stock Exchange can withhold if it sees fit. Reliable and systematic prices can only be obtained from a member, who, having the *entrée* to the market, makes it his business to collect and communicate them, and it is not only in the power of the committee to forbid this, but, if such prices are to be purveyed for the benefit of outside irresponsible agencies, it is its duty to do so. The Exchange Telegraph Company cannot afford to be reduced to obtaining prices in a furtive and haphazard way, and there is every reason to believe that they would readily accede to a proposal from the committee to cut off outsiders if such were made. Indeed, they voluntarily offered to do so some time ago, but for some inscrutable reason the committee declined the suggestion and returned evil for good by requiring them to remove their transmitting instrument from the inside to the outside of the door. This was, to say the least of it, a mistake. The Stock Exchange should extend not less, but more, facilities to the Exchange Telegraph Company. Why should it not install them on the floor of the house, where there is now plenty of room, and enable them to transmit from thence not only prices, but announcements of 'business done,' as they are handed in, and of challenges by brokers wishing to deal in out-of-the-way securities? By this means the Stock Exchange would be at once improving the market they offer the public and furnishing them with more complete information regarding it. Obviously the proper course is not to kick out the 'tape' but to invite it inside on proper terms. We say, therefore, that the Exchange Telegraph Company shall have our prices, but only on the understanding that they are supplied to such persons as shall have previously obtained the license of our committee to receive them, and to no others."

THE TELEPHONE SERVICE IN LIVERPOOL AND MANCHESTER.—A special meeting of the Council of the Liverpool Chamber of Commerce was held at the offices, Exchange-buildings, recently for the purpose of hearing a deputation from the Lancashire and Cheshire Telephone Company. The Telephone Company was represented by Mr. C. Moseley, of Manchester, chairman of the company, Messrs. G. H. Robertson, and Mr. F. W. Reynolds. The secretary of the council read a letter which had been written to the company a short time ago, asking that the rates should be reduced, on the ground that with the exception of London, Manchester, and Liverpool, the telephone charges in the United Kingdom ranged from £10 to to £14. On the Continent the general charge was rather over £7, and in no instance exceeded £10 per annum. It was understood also that the Post Office authorities were prepared to give a large body of subscribers equal facilities to those given by the company for £14. 10s. per annum. As regarded the inefficiency of the system, although some improvement had been made in the working of late, it was found that they were often cut off in conversation, without due notice; that they were frequently connected with wrong numbers; that there was want of proper attention in the switch room, and there was a want of civility; that there were disturbing noises; that communication with Manchester and Ashton was so bad that telegrams were sent in preference. Mr. H. Glasgow said when he consented to adopt the telephone in Liverpool an inducement was held out to him that when they got 200 subscribers the cost would be reduced to £10 a year, but now it was said, owing to various causes, this could not be carried out. Mr. Moseley, in reply, said with regard to communication being cut off, this was one of the most difficult things they had to contend with. He believed it arose from currents in the atmosphere or in the earth. And there might be other causes, such as contact with neighbouring wires, or a little electric leakage. The whole process was of such a delicate nature, and was influenced by such minute currents, that these things were uncontrollable at present. As to delay, this arose from various causes which were beyond their control. With regard to being put on the wrong number, they knew that in listening through a telephone it was very difficult sometimes to distinguish numbers, and even words had often to be spelt. A more serious matter was the complaint of incivility, but this could not be dealt with unless some one would notify it when it was found. With regard to distracting noises, this was one of the difficulties which science had made no remedy against. In reference to the communication between here and Ashton, the fact was they had only lately been able to extend an arm of their business to Ashton, with a single wire between Manchester and Ashton, and this was insufficient for the wants of the public, but they hoped to extend their service in that direction. As to the rates charged, he quoted towns on the Continent and in America, where the charges were higher than in Liverpool. In England the companies had to pay a tax to the Government, which came back on the subscribers, but the most serious part of the letter was the reference to the Post Office. Now, it was well known that the Post Office limited the service for £14. 10s. to a radius of a quarter of a mile, and the charge was increased in proportion to distance. The company were as anxious on behalf of the public as they were on behalf of the shareholders, but they must make such a charge as would give the shareholders a fair return for their money. They were paying now 7 per cent., but they had no reserve fund to replace the plant, and they must have that before they could be justified in making a reduction in the charge. The company were desirous of doing all they could to secure the thorough efficiency of the service. Some discussion followed as to details, after which Mr. Moseley was thanked for his statement, and the meeting then broke up.

WESTERN TELEPHONE COMPANY.—*The Western Morning News*, in a recent issue discussing the position, history, and prospects of this company, among other things, says, "The first telephone erected for practical use in the Western Counties was to connect the office of the *Western Morning News* with the residence of its editor. There are exceptional reasons, from Governmental interference, that have caused England to be behind other countries in the use of the telephone. [We demur somewhat to this statement and the inferences drawn from it following.—ED. *E.*] It seems but yesterday the newspapers announced (in 1877) to an incredulous public that a discovery had been made which enabled persons at a distance to talk with each other by means of electricity. It seemed almost absurd to suppose that the vibrations of the air caused when a person speaks should set in sympathetic vibration a sensitive diaphragm in the same way that they act upon the tympanum of the ear; that then those vibrations should be carried along an electric conductor and be reproduced on another diaphragm a long way off, thus rendering audible sounds spoken at the original source. After being closed by the Government for a

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short period, the Telephone Exchange was again opened in Plymouth on 18th December, 1884. In April of the present year a new company was formed, which took over all that was left of the old United Telephone Company, and started as the Western Counties and South Wales Telephone Company. Since then it has been bravely fighting against fortune, not so much on account of its only competitor, the Post Office, but on account of being heavily handicapped by that competitor. When the Post Office authorities closed the United Company they opened one of their own, and gave a promise to their subscribers that they would not license any other company or persons in the three towns for five years; and on that undertaking many firms pledged themselves by contract to become members for the five years. When, however, Professor Fawcett removed the restrictions, as already intimated, the promise of the Post Office came to naught, and the subscribers found themselves in the same position as if the Post Office had been guilty of a breach of agreement, as, indeed, strictly speaking, they had been. There are, therefore, two exchanges in this district, and it is pretty certain that one will have to go the wall. There can be little doubt that until the Post Office decides to do all the telephonic business of the country itself, it will really do little at all. Government never can, or rather never does, manage anything properly until the thing has proved such a national convenience that it is bound to succeed by whomsoever it is managed; an instance of which inaptitude for ordinary business is shown by the fact that the proprietors of Bell's patent telephone have refused a Government offer of many thousands of pounds for their rights, whereas a few years ago they were offered to Government for a very small figure. In these circumstances the policy of the newly-formed company was very simple. It was to endeavour to obtain on their list of subscribers those that were on the list of the Post Office telephone. The directors have seized the opportunity. They have offered to place on their list, free of charge, the Post Office subscribers until their five years' agreement determines, on the condition that for three years afterwards they become paying subscribers at the ordinary rates. The result is that there are on the company's list for the three towns ninety-five subscribers, and when this number is increased to two hundred, the company will keep their exchange open all night without any extra charge. This in itself would be a great advantage to all concerned; but the company does not stop there. They promise that if Government will remit the ten per cent. on the rental they now charge, or will make merely a nominal charge as a recognition of their rights, then the subscribers shall have the benefit of that remission by a reduction of ten per cent. in the rate of subscriptions. This is a consummation devoutly to be wished, and all the pressure that it is possible to bring to bear upon the authorities ought to be exercised as vigorously as possible."

THE ELECTRIC LIGHT IN CHELSEA.—Mr. Charles Mossop, chairman of the Electric Lighting Committee, and Mr. G. R. Strachan, surveyor to the Vestry of Chelsea, have made a report to the Vestry on this subject under these circumstances:—The Chelsea Electricity Supply Company having deposited with the Vestry a copy of the Provisional Order for which they are making application to the Board of Trade, and which, if confirmed by Parliament, will authorise them to erect and maintain electric lines and works and to supply electricity within the parish of Chelsea, the Vestry referred the whole subject to the committee. The gentlemen named above prepared a report, which was adopted by the committee, and on being submitted to the Vestry recently was approved by that body. The report states:—"The undertakers seek compulsory powers over that part of Chelsea included between Elizabeth-street, Exeter-street, and Cadogan-place on the north, and Ovington-street, Halsey-street, Cadogan-terrace, Draycott-place, Lower Sloane-street, and Little George-street on the west and south. This area includes Cadogan-place, Cadogan-square, Hans-place, Lennox-gardens, Sloane-square, and the Court Theatre, and is known throughout the order as Schedule A. Within three years from the commencement of the order, distributing mains for general supply are to be laid in the following streets:—Cadogan place and terrace, Cadogan square and street, D'Oyley-street, Draycott place and street, Elizabeth-street, Ellis-street, Grove-place, Hans-place, Lennox-gardens, Little Cadogan-place, Lower George-street, Milner-street, Pavilion-road, Pont-street, Sloane square and street, Walton place and street, York-street. At the expiration of the three years the undertakers must, on requisition, lay down mains in every other street in the area described. The capital of the undertakers for the purposes of this order is to be £100,500. If the order sought is granted, the owner or occupier of any premises within 25 yards of a main will be entitled to a supply of electricity during the whole or any part of the day, if he pays for so much of the service lines as lies beyond 30ft. from the main, and enters into an agreement to pay for a minimum supply of £14 a year for two years. He must also give security and provide proper apparatus on his premises. The maximum supply to which any single consumer will be entitled is at the rate of 1-24th of a unit in one minute. This limit, if used by any person, would make his lighting bill over £900 a year, and thus it is sufficiently ample. The owners or occupiers of premises not within 25 yards of a main, but which are in Schedule A or its additions, will be entitled to a supply of electricity if two or more of them enter into an agreement to pay for such a supply for three years as will produce an annual sum at least equal to 20 per cent. on the cost of providing the additional mains. The undertakers will be entitled to charge for a supply by any of the following methods:—1. By the quantity of energy in the supply. 2. By the quantity of electricity supplied. 3. By the number of hours during which the supply is used. 4. By agreement. The maximum price is 10d. per unit. In the Brush order it was 7d. per unit, and in the order before the committee last year it was 1s. per unit." The committee came to the conclusion that a modification of the stringent purchase section of the Electric Lighting Act, 1882, is necessary, if electric lighting is to be secured to the public at the present time. They, therefore, had conferences with the promoters, and prepared a clause in lieu of Section 27 of that Act, the effect of which will be as follows:—To give the company 35 years' purchase instead of 21. To authorise the local authority to pay to the undertaker "for all lands and buildings belonging to, and for all materials in store within such jurisdiction necessary to such undertakers for the purposes of their undertaking within such jurisdiction, such a price as would be paid by a willing purchaser to a willing seller in the open market; for all works, machinery, and plant not included in the above, the fair market value of the same, as necessary and in use for such generation and distribution. Such values to be in case of difference determined by arbitration. And in neither case shall any allowance be made for compulsory sale, nor in the basis of calculation of such values shall the actual or future profits of the undertaking at the time of sale be taken into consideration." The promoters of the undertaking have agreed with the Vestry upon the form of the order indicated in the foregoing report.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 107.)

A network of linear dielectric conductors, or of shunted condensers.

Let any number of points be connected by linear conductors, thus forming a network of any degree of complexity. They will be referred to as Branches. Let each branch consist of any number of conductors in sequence, to be called the Shunts. Let every shunt have its ends joined to the poles of a condenser by wires whose resistances we do not count. This makes the combination complete. We have a linear combination of inductive branches exactly similar to the conductive; they are side by side, as it were, and in connection at certain points. We may regard the conductors as shunts to the condensers, or the other way, as we please, but the former plan is perhaps the best.

Instead of thus shunting the condensers by external conductors, we may do away with the shunts, giving instead equal conductances to the condensers themselves, thus making a combination of unshunted leaky condensers.

Or, we may abolish the external condensers, and give equal dielectric capacity (uniformly distributed *in* the wires) to the former shunts themselves, thus making a network of dielectric conductors. The theory is in all cases the same, with certain exceptions as regards the effects of impressed force and of electro-magnetic induction. In many respects the theory is most simply expressed by having the two qualities, conductivity and dielectric capacity, coincident, as in the dielectric conductors, instead of side by side, as in the case of the shunted condensers.

If the shunted condensers were all disconnected from one another so as to form independent circuits, partly conductive and partly dielectric, any charges they might have would discharge through their shunts, each charge at its proper rate depending upon the time constant of the condenser concerned, which is rp, if r be the resistance of the shunt and p the capacity of the condenser (inertia is ignored). When they are in connection, as above described, the time constants of the normal systems will all lie between the greatest and the least of the time constants of the separate shunted condensers. If these be all equal, there is but one time constant, viz., the common value of rp. In this case, if the condensers be charged in any manner and then be left in connection without impressed force anywhere in the system, the charges will at once readjust themselves to a new distribution, to be found by the two considerations that the E.M.F. in any circuit in the new state is zero, and that the charges that disappear form a system of closed displacement in the combination. This new state will then subside uniformly everywhere, each condenser discharging through its own shunt. If an impressed force be introduced at the junction of two shunted condensers, say in an infinitely short wire joining one shunt to the next, it sets up the appropriate state of conduction current in the branches and of charge in the condensers instantly; these charges are equal in all the condensers in one branch, and in different branches are simply proportional to the currents in the branches. The same will be true if the impressed force be in a shunt, if there be an equal and similarly directed impressed force in the corresponding condenser. (In the case of the dielectric wires there is no need for this reservation.) But if the impressed force be in a shunt only, the charge of its condenser will be opposite to that of the others in the same branch, and there will be retardation according to the common time-constant. Thus, if the condensers be charged in any manner which could be produced by impressed forces in any of or all the branches (equally in shunts and condensers), and be left to themselves, the subsidence is instantaneous. There is only retardation in connection with those parts of the system of charges which could not be produced in the described manner. And, considering electro-magnetic induction, if it operate equally on conductor and dielectric, as in the case of the dielectric wires, it will only affect the discharge of the parts that before subsided instantly, the subsidence being no longer immediate; whilst the other parts will subside just as before, independently of inertia; for as the conductive and dielectric currents are equal and opposite, there is no true current and no electro-magnetic induction in connection therewith.

The above are conclusions from the general theory in the last section. As regards the proof of the limits between which the time constants must lie, let E be the E.M.F. in any condenser, p its capacity, and k the conductance of its shunt. Then, in any normal system, if Q be the dissipativity and U the potential energy,

$$\Sigma(k+pn)E^2 = Q + 2nU = 0,$$

the Σ to include all the shunted condensers. If n do not lie between the greatest and least values of $-k/p$, the summation cannot vanish, as it must; therefore every n does lie between these limits.

The differential equation of the combination, and the determinantal equation of the rates of subsidence, are most directly found by the method used in the paper on Induction in Cores, when treating of combinations of coils. The sum of the steps of potential in any circuit must be zero; get, then, the expression for the step of potential between any two points in terms of the currents, and we have one equation for every circuit. Eliminate the currents by their conditions of continuity, and the result is the differential equation, or the determinantal equation, according as we treat d/dt as the differentiating operator or as a constant.

In the present case, if Γ be the sum of the currents in a shunt and in its condenser, reckoned the same way in both (or the true current in the dielectric conductor), we have

$$\Gamma = (k+pn)E,$$

if n stand for d/dt. Every condenser has an equation of this form. Here E is the fall of potential through the shunt and through the condenser. Since Γ is the same along the whole of any one branch, the fall of potential between its ends is

$$\Gamma\Sigma(k+pn)^{-1},$$

the Σ to include all the condensers in the branch. Hence, if the combination consist of only one closed circuit,

$$\Sigma(k+pn)^{-1} = 0,$$

when cleared of fractions, is the differential, or the determinantal equation, according as n is d/dt or algebraical. That is, we equate the (generalised) resistance of the circuit to zero. Thus, if there be three condensers, and y stand for $k+pn$, the equation is

$$(y_1)^{-1} + (y_2)^{-1} + (y_3)^{-1} = 0\text{; or, } y_1y_2 + y_2y_3 + y_3y_1 = 0.$$

The determinantal equation of m condensers in one circuit is of the $(m-1)^{th}$ degree; one freedom is lost. The missing root is the negative infinity root of the instantaneous subsidence. To bring it to finiteness, put in the circuit a conductor without condenser. Then *its* y is its real conductance, say k_0, and the equation is

$$k_0^{-1} + \Sigma y^{-1} = 0.$$

This has the full number m of roots.

Let $q_1, q_2, \ldots$, be the charges and E_1 $E_2, \ldots$, be the E.M.F.'s of the condensers of capacity $p_1, p_2, \ldots$, whose shunts have conductances $k_1, k_2, \ldots$, going round the circuit in the + direction of Γ. A charge is + when the displacement is in the + direction. Then we have

$$q_1 = p_1E_1, \qquad q_2 = p_2E_2, \qquad \text{\&c.}$$

or, $$q_1 = p_1\Gamma/(k_1+p_1n), \qquad q_2 = p_2\Gamma/(k_2+p_2n), \qquad \text{\&c.}$$

Therefore, in a normal system, the ratios of the charges are

$$q_1 : q_2 : \ldots = (k_1/p_1+n)^{-1} : (k_2/p_2+n)^{-1} : \ldots = p_1/y_1 : p_2/y_2 : \ldots,$$

and thus we have m sets of ratios, by giving to n its m values in succession. To determine the absolute size of a particular normal system, use $U_{12}=0$, taking $p_1/y_1, \ldots$ as the normal functions. If A be their common multiplier, we get

$$A = (\Sigma Dy^{-1}) \div (\Sigma py^{-2})$$

if D_1, D_2, &c., be the initial charges.

When, by shortening the wire k_0, we send the root depending upon its presence to $-\infty$, the above ratios become $1:1:1:\ldots$

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in the normal system of this root. Taking, then, 1, 1, 1, as the normal functions,

$$A = (\Sigma D p^{-1}) \div \Sigma p^{-1}$$

gives the common charge of all the condensers that instantly disappears. It is the charge due to the initial E.M.F. in the circuit. Its disappearance makes the electric force polar.

If all the time constants p/k of the separate condensers are equal we have $y=0$ repeated $(m-1)$ times. The charges at time t are therefore

$$q_1 = (D_1 - A)\epsilon_0, \qquad q_2 = (D_2 - A)\epsilon_0, \qquad \text{etc.,}$$

where $\epsilon_0 = \epsilon^{-kt/p}$, and A is given by the previous equation.

So far relating to a single closed circuit, the next simplest case is that of any number of branches uniting two points. Here the sum of the currents leaving either point is zero. If $\Gamma_1, \Gamma_2, \ldots$, be the currents in the branches, all reckoned parallel, $p_{11}, p_{12}, \ldots$, the capacities in the first branch, $p_{21}, p_{22}, \ldots$, in the second, with a similar notation for the other quantities, we have

$$\Gamma_1 = (k_{11}/p_{11} + n)q_{11} = (k_{12}/p_{12} + n)q_{12} = \ldots,$$
$$\Gamma_2 = (k_{21}/p_{21} + n)q_{21} = (k_{22}/p_{22} + n)q_{22} = \ldots,$$

&c., and the sum of the Γ's is zero. These give the determinantal equation.

$$(\Sigma y_1^{-1})^{-1} + (\Sigma y_2^{-1})^{-1} + (\Sigma y_3^{-1})^{-1} + \ldots = 0,$$

each summation to include all the y's in one branch only. That is, the sum of the generalised conductances of the branches in parallel is zero.

The number of missing roots is one less than the number of branches. The full number, equal to the number of condensers, may be got by inserting condenserless conductors in all the branches except one; if in that one also, it makes no difference in their number, though altering their magnitude.

If there be no inserted condenserless conductors, it will be necessary to determine what part of each charge instantly disappears. We have to make the electric polar force, and therefore equalise the E.M.F.'s in the different branches reckoned the same way between the two points, and do it by making equal changes in the initial charges in any one branch. The charges q at time t, after they were given D, are, if k/p is the same for every condenser, given by

$$q_{11} = (D_{11} - A_1)\epsilon_0, \qquad q_{21} = (D_{21} - A_2)\epsilon_0, \text{ \&c.}$$
$$q_{12} = (D_{12} - A_1)\epsilon_0, \qquad q_{22} = (D_{22} - A_2)\epsilon_0, \text{ \&c.}$$
&c. &c.

where ϵ_0 is, as before, the time function of the repeated root, and there is one A to be found in each branch. It will not be necessary to take up space by describing how they are got in this special case, or in writing them out, as the following method, applicable to any combination, will apply.

In any network of linear conductors there is a certain number of degrees of freedom, *i.e.*, the number of branches in which the currents must be given in order that they may be known in all the rest. Thus, in the common "bridge," the currents in three branches being given, those in the rest follow.

[If m points be joined by $m(m-1)/2$ conductive branches, the number of current freedoms is $(m-1)(m-2)/2$. This is $(m-1)$ less than the number of branches.]

This number of current freedoms is just the number of the missing $(-\infty)$ roots in the determinantal equation when the branches have condensers connected along them as described at the beginning. As for the equation itself, if the characteristic function of the conductive combination be known, it may be got by turning every k into $k+pn$ in it, and equating the result to zero. [The characteristic function is of the degree $(m-1)$ in terms of the conductances (one less than the number of points); hence, when for k we put $(k+pn)$, the determinantal equation is of the degree $(m-1)$ in n, so that the roots are fewer in number than the branches by the number of current freedoms in the conductive network, if there be but one condenser in each branch, and fewer in number than the condensers by the number of current freedoms in the conductive network if there be many condensers in each branch. If, on the other hand, there are no condensers, but we take account of the self-induction of every branch, we get the determinantal equation by turning k into $(k^{-1}+sn)^{-1}$, if s be the self-induction coefficient of a branch. There will now be $(m-1)$ fewer roots than the number of branches.] Now, suppose k/p is the same for every condenser, and we want to know how the initial charges subside. Let us number the branches 1, 2, 3, &c., and choose (arbitrarily) a certain direction in each for the positive direction in which the current, E.M.F., and charges (displacements) are reckoned. Let every capacity have two suffixes, the first to denote which branch is referred to, the second to show its position in the branch, and do the same with the charges and the conductances. The currents Γ only want one suffix to show which branch is referred to. We have, then, in the case of the infinity roots, if A_{11}, &c., are the charges that disappear,

$$A_{11} = A_{12} = A_{13} = \ldots = A_1 \text{ say,}$$
$$A_{21} = A_{22} = A_{23} = \ldots = A_2 \text{ say,}$$

&c.; that is, the same portion of the charge of every condenser in one branch disappears instantly. Besides that, $A_1, A_2, \ldots$, in the different branches, are connected together by the same conditions of continuity as the currents in the different branches. That is, $A_1, A_2, \ldots$, form a system of closed displacement.

The solution is therefore of the same form as in the previous equations, and we have only to find one A for each branch to complete the solution. Initially, we have

$$D_{11} = A_1 + (D_{11} - A_1), \qquad D_{21} = A_2 + (D_{21} - A_2), \text{ \&c.}$$
$$D_{12} = A_1 + (D_{12} - A_1), \qquad D_{22} = A_2 + (D_{22} - A_2), \text{ \&c.}$$
$$D_{13} = A_1 + (D_{13} - A_1), \qquad D_{23} = A_2 + (D_{23} - A_2), \text{ \&c.}$$
&c. &c.

The system of the A's is closed. That of the (D − A)'s is such that its electric force is polar. The mutual energy of the latter and any closed displacement is therefore zero. The mutual energy of the D's and any closed displacement is therefore equal to that of the A's and the same. Let this "any closed displacement" be the charges set up in the system by a unit impressed force in any branch (equally in shunt and condenser). For instance, let d_{11}, d_{12}, d_{13}, be the charges of the condensers in branches 1, 2, 3, &c., due to unit impressed force in branch 1. Then the mutual energy of the D's and d's equals that of the A's and d's. But the latter equals twice the product of the impressed force of the d's into the displacement of the A's; or, since the impressed force is unity and is in the branch 1 only, it equals $2A_1$ itself. Hence A_1 is one half the mutual energy of the D's and d's. Or,

$$A_1 = d_{11}\Sigma D_1/p_1 + d_{12}\Sigma D_2/p_2 + d_{13}\Sigma D_3/p_3 + \ldots$$

where the first Σ relates to branch 1, the second to branch 2, and so on.

Similarly, if $d_{21}, d_{22}, d_{23}, \ldots$, are the charges in 1, 2, 3, …, due to unit impressed force in 2, we have

$$A_2 = d_{21}\Sigma D_1/p_1 + d_{22}\Sigma D_2/p_2 + d_{23}\Sigma D_{23}/p + \ldots.$$

Thus the A's are known in terms of initial charges and of the d's. The latter may be found in precisely the same manner as the current in the branches due to the unit impressed forces. In fact, instead of mutual energy, we may employ the idea of mutual dissipativity and activity. Let $\gamma_{11}, \gamma_{12}, \gamma_{13}$, &c., be the currents in 1, 2, 3, … due to unit impressed force in 1. Then

$$A_1 = \gamma_{11}\Sigma D_1/k_1 + \gamma_{12}\Sigma D_2/k_2 + \gamma_{13}\Sigma D_3/k_3 + \ldots,$$

is an alternative form of A_1. In the reasoning we should now imagine the D's to be currents (not closed), and the A's closed currents, and speak of mutual dissipativity or of activity. The matter is therefore reduced to the problem of finding how current due to impressed force in any branch divides through the conductive system. [When the time constants of the condensers (shunted) are not equal, the charges that are left after the first readjustment require to be decomposed into their proper normal systems, to be done by the $U_{12}=0$ property. This does not present anything unusual.]

The following is the tridimensional representative of the above method of finding the A's. Referring now everything to the unit volume, let D_0 be the initial displacement, and p the capacity. Divide D_0 into two parts, of which one is closed, whilst the electric force of the other is polar. That is, let

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A be the closed displacement, so that

$$\text{div. } A = 0, \qquad \text{curl. } (D_0 - A)/p = 0,$$

find A. The mutual energy of D_0 and any closed displacement equals that of A and the same, because the force $(D_0 - A)/p$ is polar. Let the any closed displacement be that due to unit e at any point, and call it d. Then

$$\Sigma d D_0/p = \Sigma d A/p = \Sigma(e+f)A$$

if f is the polar force of e,

$$= \Sigma e A = \text{tensor of A at the place of } e,$$

if e be parallel to A.

Thus we know the distribution of A as soon as we know the displacement due to impressed force.

(*To be continued.*)

MAGNETISM.

BY WILLOUGHBY SMITH.

(*Continued from page 129.*)

Amongst the foremost labourers in this new field of research was Ampère, who soon discovered that when two metal bodies are suspended or supported so as to be capable of moving either towards or from one another at the time that electrical currents are passing through them, they manifest a mutual attraction or repulsion, according as the currents are moving in the same or opposite directions. This phenomenon Ampère called electro-dynamics. M. Arago, in France, and Sir H. Davy, in England, about the same time made known that if a metal wire, while being traversed by an electrical current, be plunged into iron filings it will retain around it a considerable quantity of the filings in the form of a cylindrical mass, the thickness depending on the strength of the current, and that immediately the circuit is broken the filings fall. This phenomenon further proved the magnetic properties of the wire while under the influence of an electric current. The following notes are from results of similar experiments which I have made in this direction. The current must be of great strength to produce an appreciable effect; for instance, five amperes through a copper wire ·018 of an inch diameter. The larger the diameter of the wire the greater must be the current strength. Two Grove cells were sufficient to produce the effect with a very short length of wire, the greatest weight supported at any part of the wire being about 1 grain. Very fine iron filings settled round the wire, giving it the appearance of a circular brush. Copper, iron and aluminium all gave identically the same results, but with tin, zinc, and lead the necessary current could not be used on account of their low melting point. Arago and Davy also found that a steel needle became more strongly magnetised if the magnetising wire were bent into a helix and the needle placed in the axis of the helix, instead of the conductor remaining rectilinear.

The knowledge of this fact led to discoveries still more startling, for it was soon found that if a rod of soft iron were placed in a helix formed of a wire of any conducting metal covered with an insulating material, a feeble current was sufficient to impart powerful magnetic properties to the iron rod, more especially if the rod were formed in the shape of a horseshoe so as to permit of both ends being used to attract the same substance. The magnetisation was instantaneous, appearing immediately the helix was connected with the battery, and ceasing, almost entirely, as soon as the circuit was broken. Such an arrangement was called an electro-magnet, and this discovery caused a great advance in the science of magnetism, for it furnished a means of acquiring immense, if not an unlimited, magnetic power.

Experimenters soon gave their attention to determining the conditions most favourable to the development of powerful electro-magnets, and the published results of some of their labours are so remarkable that it cannot be deemed unjust to suppose that their ambition to excel each other took possession of their imagination and left their reason unemployed. However, some of their experiments produced very curious, interesting, and valuable results. For instance, it was found that if a helix of insulated copper wire be placed horizontally, and one end of a rod of soft iron be presented at one end of the helix, it will be attracted into the helix, and place itself so that its centre coincides with that of the helix, the result being the same whether the rod is shorter or longer than the axis of the helix. Again, a ball of soft iron of any diameter, providing it is not too large to enter the helix, when placed at the opening of the helix and being free to roll upon a very horizontal plane, in like manner rushes in and stops at the centre. So powerful can the action of a helix of this description be made, that if a magnetised needle or bar be placed within it so as to rest upon the lower portion of the helix, the moment the battery is connected to the helix the needle or bar will place itself in the axis, and so long as the circuit is maintained, remain suspended in the air in opposition to the force of gravity. In the centre of a vertical helix connected with a powerful battery, I have so suspended a rod of iron 3ft. long and 1·25in. in diameter, totally free from any material connection or support.

A helix of insulated wire enclosing an iron core and electrically excited not only makes that iron a magnet, but is itself a magnet, and has a sphere of magnetic lines of force surrounding it independent of the lines of force given out by the iron which it surrounds, and the more intense the current passing through the helix the more intense will be the magnetic lines of force. This should be borne in mind when experimenting with helices or iron rods separately or combined. The law of action and re-action being equal and opposite, it might be expected that, as electricity produces magnetism, so, conversely, magnetism ought to produce electricity. Thus, no doubt, reasoned Faraday, and the results of his experimental research in that direction brought to light several most valuable discoveries. Faraday wound a certain length of insulated copper wire round a cylinder of wood, and over this helix he wound a similar length of insulated wire. One of these helices he connected with a galvanometer, and the other with a voltaic battery; when the battery contact was made he noticed a sudden effect at the galvanometer, and a similar effect when the contact with the battery was broken, but in the opposite direction to the first deflection. This and similar phenomena Faraday called volta-electric induction. He then wound similar lengths of insulated copper wire separately on to sections of a welded ring of soft round bar iron. When one of these helices was connected to a galvanometer, and the battery to one of the other helices, much greater results were obtained than with helices wound on wood. When a charcoal point was fixed to each end of the wire of one helix, and these points were brought close together, a minute spark could be perceived each time contact with the battery was made with one of the other helices. He also found that whenever the end of a magnet was passed suddenly into or out of the centre of a hollow helix of wire connected with a galvanometer, strong deflections were produced, but the direction of the deflection depended on the movement of the magnet. When entering the helix the galvanometer was affected in one direction, and when leaving it was affected in the opposite direction. The same results were obtained if the magnet were fixed and the helix movable. This agency, excited by ordinary magnets, Faraday called magneto-electric induction. Thus Faraday proved that electrical currents can be produced by magnets the same as magnetic effects are produced by electrical currents, but he believed they differed in one important respect, viz., that time is required for the development of magneto-electric induction, whereas he considered volta-electric induction to be instantaneous; but the latter is not borne out by the results of my published experiments on volta and magneto-electric induction. It was while engaged in those experiments that Faraday coined and circulated the terms "line of magnetic force," or "magnetic lines of force," "magnetic curves," "line or lines of electric force," "magnetic or electric fields," &c.

Magnetism has ever been a fertile field for hypothesis, and the discovery of electro-magnetism increased rather than diminished the confusion created by the number of theories that were promulgated to account for so remarkable a phenomenon. If the reasoning of some had been correct, it would have been necessary to have ignored the fact that man cannot create, destroy, or in any way alter the mysterious power with which the Almighty has endowed matter, which power is designated, for the want of more knowledge, gravity, heat, light, electricity, magnetism, and so on.

The analogy which exists between the phenomena of magnetism and those of electricity are such as to warrant the suggested probability that the theory which applies to the one might, with equal justice, be attributed to the other. Thus arose the one-fluid theory of Apinus for magnetism, which is similar to Franklin's theory of electrical induction. The foundation of the hypothesis of two magnetic fluids, which is in many instances similar to Du Fay's two-fluid theory of electricity, was laid by Colomb. Faraday assumed that all the particles of matter were *not* polar in their normal state, but became so by the influence of charged particles when either in contact or in sufficiently close proximity to them, the particles thus polarised being in a forced state, and endeavouring to regain their normal or natural condition. Thus his hypothesis that induction, which always precedes conduction, is an action of contiguous particles consisting in a species of polarity. The great similarity of action between common magnets, electro-magnets, and electric currents furnishes powerful reasons that the action is the same in all cases; consequently the theory which applies the more correctly to the one should apply equally to the other. The further I extend my experimental research either in electricity or magnetism, the more strongly do I become converted to the belief of the correctness of Faraday's views concerning these matters; but I am inclined to differ from him on one most important point, for I assume that each atom of matter possesses in itself all the properties of a magnet,

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and, consequently, emits its own lines of force; and, I further believe, that the molecular attraction known as "cohesive force" is one of the results of this all-pervading system of polarisation. Each atom existing in a polarised state it follows, I think, that the outer ones, which form the surface of the earth, affect and are affected by the atoms of the air and other atoms in contact or in close proximity to them, and thus the system of polarisation is continued in curved lines throughout the whole atmosphere surrounding the earth, and constitutes what is termed "terrestial magnetism." If this be so, it therefore follows that all particles of matter, solid, liquid, or gaseous, are in a polarised state, and consequently emit lines of force.

These lines arrange themselves so as to be in a position symmetrical to the lines of force emitted by any other body, the earth's magnetic field for instance; that is to say, the strongest polarised lines will control the weakest, and direct and attract them, as illustrated by gravity. But when forced from their normal position of equilibrium by any external agency, it depends on the energy of the same whether heat, light, or sound be developed separately, or the whole three combined, as instanced by the heat generated in a magnetic field, the light produced from it, the hum of the insect or other more significant causes, or the three combined, as in the lightning's flash and the thunder's peal. As soon as the cause of each phenomenon no longer exists, the lines of force regain their normal condition, and all is once more quietude.

All matter conducts electricity, but not in the same degree, in fact it is difficult with some substances to detect their conductibility. With an increase of temperature gutta percha and such like dielectrics decrease in resistance, while with copper and other good conductors their resistance is increased under the same conditions. All matter does not polarise to the same degree; in fact, with our present knowledge of instruments for this line of experimental research, we are only able to speak in positive terms of comparatively few; but with these few we learn that temperature affects polarisation, and perhaps, if sufficient variation of temperature could be obtained, it might be found that, under certain conditions, lines of magnetic force might be made manifest from bodies which at the present time we least suspect. I assume it is not possible to decrease the normal amount of polarisation of atoms, but that it can be increased up to a certain point by external influences, as instanced by the conducting properties of matter, which is, I think, the result of forced polarisation. But if an attempt be made to exceed the maximum specific capacity for polarisation of any combination of atoms forming the material under experiment, then will be developed all the phenomena just mentioned, and eventually, if carried too far, disruption occurs, a phenomenon well known to electricians, and manifested generally in the destructive effects of lightning.

Of course, in a mere pamphlet such as this, it is impossible for me to notice all that has been done by eminent physicists in advancing our knowledge of magnetism. My object has been to give a simple and brief outline, and in so doing to call attention to some of the most prominent points in connection with the history of the same, which, perhaps, might prove of service to the earnest student, in leading up to a better undertanding of the experiments which I am about to describe.

Having now completed my task so far, I will at once proceed to give the results of some experiments I have thought it necessary to make as opportunity offered to assist me in my search after the truth concerning that most wonderful phenomenon of nature which we call magnetism.

Faraday says that a magnetised steel ring shows no external sign of power, because the lines of force of one part are continued on by every other part of the ring; and he instanced this assumed condition, with a view of strengthening *his* hypothesis. But, if such a state of things did really exist, then, in my opinion, the hypotheses I have ventured to bring forward could not be maintained; for, as I understand it, no atom or combination of atoms in any form, animate or inanimate, liquid, solid, or gaseous, can exist in an unpolarised state or without possessing magnetic lines of force. It must, of course, be understood that the external lines of force would be much stronger from a piece of metal in the form of a bar or horseshoe than they would be if the same were made into a continuous ring, assuming each to be polarised to the same intensity. As already intimated, I assume that each atom composing our atmosphere is in a state of polarisation, and is influenced by the magnetic force emanating from the earth. The magnetic lines of force given out by each polarised atom of air in turn affect, more or less, each atom of matter immersed in it; and these atoms in a similar way throw out their own lines of force, and the intensity of these curved lines is no doubt influenced by the nature and form of the material from which the lines emanate. I know of no means by which the accuracy of all such views as these can be experimentally proved unless it be admitted, which I believe to be the case, that the force which is called gravity is the effect of such an universal system of polarisation with which God has endowed all matter.

Iron, especially when in a soft state, is very susceptible of polarisation from the effects of what is called terrestrial magnetism (the polarised atoms of the air); in fact, it is as difficult to keep it from being affected by polarisation as it would be to manipulate a sponge in a liquid without its becoming more or less saturated with it.

In my endeavours to experimentally demonstrate the existence of magnetic lines of force, I generally employed the following very simple but efficient arrangement, which measures the intensity and shows the direction of the lines of magnetic force emanating from "magnetic metals," in a closed ring or in any other form, artificially magnetised, or "unmagnetised," as it is said to be, when it has not been directly influenced by a natural or artificial magnet. This arrangement is shown in Diagram II., in which A represents a short thin steel magnet suspended top and bottom by a single silk fibre in the centre of a small vulcanite or wooden frame. On one side of the magnet is fixed a small thin circular lensed mirror; the magnet, mirror, and method of suspension being similar to that generally adopted in Sir William Thomson's mirror reflecting marine galvanometers, the magnet, mirror, and fibre weighing in all about two grains; B, represents a lamp, or any convenient source of light, so placed that a beam from it will impinge on to the mirror; which reflects it on to a graduated scale, C, placed at the proper distance to receive it in the form of a well defined vertical beam about ·1 of an inch in width and 1·0 in height. The mirror, lamp, and scale should be adjusted so that when the magnet is parallel with the lines of the earth's magnetic force, the reflected beam stands at zero on the scale. In an arrangement of this kind the resistance to its motion presented by the air, and the torsion of the fibre is so slight that the angle of the deflection of the magnet is. as far as could be ascertained, directly proportional to the force affecting the same to any degree within the limits of the scale, and from such delicacy great accuracy is insured. D represents a stand, placed at the back of the magnet, on which the body under experiment is manipulated. This stand should be in no way connected to that on which the magnet is placed, in order that all disturbances from mechanical movements and other causes may be prevented from affecting the magnet. The number of interesting and instructive experiments which can be made by the aid of this simple arrangement will not be apparent at first sight, but as the experimenter proceeds he will find that as soon as he has settled one question to his own satisfaction another will suggest itself.

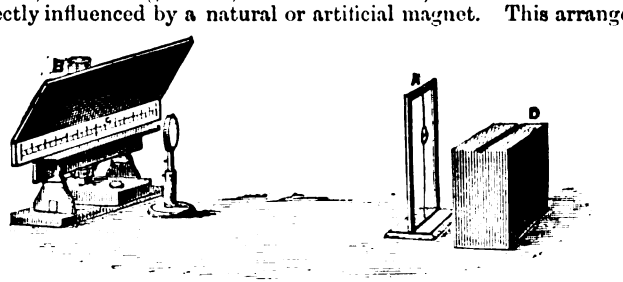

Diagram II.

A rod of annealed charcoal iron 10in. in length and ·31in. in diameter, the length being divided by marks into twenty equal parts, was placed in a groove on stand D, and at a distance of 6in. from the magnet. The positions of both magnet and rod were north and south, consequently they were parallel to each other. The north end of the rod was first placed exactly opposite the centre of the magnet, and the deflection of the magnet noted, the rod of charcoal iron being polarised by the earth's magnetism alone, or, to speak more correctly, by the polarised molecules of air in contact with it; the rod was then slowly moved in the same straight line towards the north, and the deflection noted every time one of the marks on the bar was opposite to the centre of the magnetic needle.

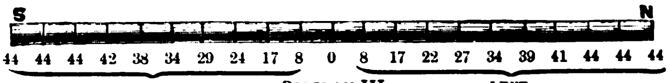

Diagram III.

The results are shown in Diagram III., where it will be seen that at or near the end pointing to the north the deflection produced is at a maximum to the left of the scale, and that, as the rod is moved, the deflection gradually decreases until the centre of the rod is at right angles to the centre of the magnet, when all influence of the rod upon the magnet apparently ceases; but, as the movement of the red proceeds, the magnet becomes again affected, but in the opposite direction, the deflection being to the right of the scale; and it gradually increases until the south end of the rod is at right angles to the centre of the magnet, when the maximum is again reached. Other results observed with this particular specimen of iron showed that the amount of magnetism and direction of polarity induced depended upon the position in which the rod was held; and, consequently, if the position were changed the intensity and polarity were also changed.

(To be continued.)

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XV.

Volume XV. of "The Electrician," price 10s. 6d., is now ready. Also cases for binding, price 2s.

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1885.

A year ago we devoted a considerable space to discussing the why and the wherefore of the position and progress of applied electricity, as well as to recording the work of the year. The time seemed opportune. There were indications of activity, but those indications have not all been realised in actual work. On the whole, however, the candid observer cannot have failed to see great progress—legitimate progress—during the year now past. We do not intend to go over the same ground at present. The time which has elapsed is too short, and the conditions altogether against any startling advance. Company mongers would have us think otherwise; but the company mongers have had their day, and must rest satisfied with their spoil. Never again will the electrical boom be so easily worked as it was in 1882-3. The future student of English idiosyncrasies will be surprised to find on the one hand how vehemently we rail against foreign competition, whilst on the other how easily any foreign dodge empties our pockets. We pointed out a long time ago that the electrical wares for which English capital was asked to pay, and did pay, were almost entirely of foreign extraction. Americans, French, Germans, Belgians—all rushed to make their harvest with the crudest of crude ideas and apparatus. Figures were made to prove anything, and fools subscribed their millions. A host of these parasites is still hanging about desirous of again commencing operations; but we are glad to find that electrical work of all kinds is progressing in the hands of private firms, while it is hardly as successful in the hands of huge companies. There is room and work, however, for two or three such companies, and no doubt the natural process of the survival of the fittest will leave in operation those that are soundly constituted.

The pecuniary harvest, as far as electrical work in 1885 is concerned, has been from few sources. Probably lawyers have gained more out of electrical business than any other class, for scarcely a week has passed but two or three cases have been before the Courts.

Government requirements for ship lighting, and similar lighting for private firms, have kept the Brush Company, Crompton and Co., Johnson and Phillips, Siemens and Co., and the Swan Company, fairly busy in building dynamos, making lamps, and carrying out the installations. Among engine builders who make a speciality of engines for ship lighting, Messrs. Willans and Robinson have rapidly come to the front, and the concensus of practical opinion is that their engines are the best at present constructed for this class of work. Turning from ship lighting to house and street lighting, we find the firms of Davey, Paxman and Co., Marshall and Sons, and Ransomes, Sims, and Jefferies paying close attention to the work and taking the lead so far as engines are concerned. The mention of steam engines brings us to the text upon which this portion of our article hangs. The enormous services of steam are too well known to require description. The present generation, which can hardly imagine a world without steam power, can easily foresee a still further development. In our opinion, whatever be the utility of steam, whatever be its development, it will be ere long—perhaps before the beginning of the next century—altogether outstripped in the race by electricity. The uses to which electricity can be put are numberless, and its help will be more and more widely sought. Luxury and necessity alike go hand in hand in demanding the application of this wonderful agent. There seems to be no single operation in the cycle of the world's works for which its aid cannot with benefit be invoked. Many writers have predicted uses to which it has not yet been put, but neither the wildest imagination of the novelist nor the trained mind of the man of science has been able to give more than a glimpse of the probable value of its future applications. The practical annihilation of space, so far as communication is concerned, is an actual fact. Under oceans, over rivers and mountains, the message is transmitted, so that, if necessary, a drawing room in Antipodean New Zealand may communicate with a drawing room in London. Another application has enabled us to converse through shorter distances; but, as time moves on and conditions are better understood, the distance through which converse may be held will be increased. Then, we hear from time to time rumours indicating that light as well as sound may be brought under control. Outsiders, as a rule, do not in these days of scientific surprises attempt to obtain a knowledge of the rudiments of science; hence the multitude fancies there ought to be little difficulty in controlling light, when we have in some measure harnessed and made subservient the sister phenomenon "sound." When they know or when they recollect that light waves are waves of an imponderable ether, and that sound waves are waves of ponderable matter, they may be able to perceive the difficulties to be overcome before a solution of the problem is found.

Glancing at more prosaic but equally useful matters, a good deal is known as to the possibility of transmitting power by

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means of electrical apparatus; but the most we can say in this direction is that at present power can only be transmitted economically when the conditions are favourable. Inventors and promoters are straining in the leash to enter into this hunting ground. Hence it is necessary at all times to utter a word of warning to the unwary lest they should be caught napping. The waste energy of Nature may be transmitted and utilised over comparatively short distances, and as the original energy costs nothing, such transmission may be economical. Energy obtained by the combustion of coal, or zinc, &c., is more economical when applied direct than in any indirect manner.

The application of electricity to the giving of light is really in its infancy, though for the past five years it has been the most prominent application. Here we obtain a decided gain in not using directly the light from the combustion of coal. The reasons are not far to seek, and need no recapitulation. The value of the electric light is after a manner admitted, but though admitted it is not understood. Though physiologists have thundered its innocent properties in the ears of the world, the world prefers dirt and the germs of disease to cleanliness and healthiness, because the latter are not immediately and overwhelmingly cheaper than the former. We cannot understand why, when the question of warmth has not to be considered, gas is for a moment tolerated. The electric light is in every way its superior, and even were the annual bill double or treble that of gas, it would be, paradoxical as it seems, by far the cheaper illuminant. This statement refers only to interior lighting.

When we come to street lighting we maintain that, for every reason, we should have more light. Far more business could be done in the busy streets of London at a less cost, so far as horse-flesh and wear and tear are concerned, were there more light. We are glad that the close of the year has seen the arrangement made with the Brush Company to furnish more light to a portion of the City.

Passing onward to other applications of electricity, surely even now their name is legion. By its means we ring our bells, we guard our houses and our safes—or we might do so if we chose; and to do so will, in the not far distant future, be the rule and not the exception. The doctor and the dentist call upon its aid, and it is gradually forcing a greater attention to many of its properties from all medical men. In warfare it is used for signalling purposes, for firing, for training guns, in torpedo work, and in a hundred different ways; in peace it is ubiquitous. Wherever we look we find its use increasing. A grand and at present an almost untrodden field is opening in chemical and metallurgical work. Its possibilities are, indeed, as vast as its operations are wonderful.

The briefest consideration will show that it is of the utmost importance that the younger generation should be well grounded in the fundamental laws which govern this extraordinary agent—that a thorough knowledge of the subject should lead to positions where the remuneration would be ample and the opportunities abundant The watchword, however, should be "thorough." Mediocrity here, as elsewhere, will have to be satisfied with a back seat, while "knowledge" will mean "money." Hand as well as brain must be cultivated, and the result will be satisfactory.

From all points of view the most important part of the telegraphic history of the year is centered round the Berlin Conference. The meeting made a considerable number of alterations, which have not yet come into operation, and the effects of which, therefore, cannot as yet be foretold. In the following paragraphs an attempt has been made to give the salient points of the work of the Conference.

In August last the usual Quinquennial International Telegraph Conference was held at Berlin, where almost every State in the world—excepting the United States and Canada—was represented, and the British Submarine Telegraph Companies were also invited to attend, with liberty to speak but not to vote. The main topic discussed was the tariff for European telegrams, Germany and Austria having proposed the adoption of a low, uniform rate for telegrams sent from and to any country in Europe.

At first blush the proposition approves itself to the minds of everybody unconnected with the telegraph service, the uniform postal rate being of great public convenience; but there is a wide difference between telegrams and letters. Any number of letters may be forwarded with very little, if any, additional cost to the State, but the number of telegrams is limited by the number of telegraph lines, and in the case of cables their capacity will not admit of a sufficient number of words being transmitted at a very low rate to cover the interest on the cost of construction, as well as the charges for maintenance and working.

At the present time the tariff of the submarine cables between all countries in Europe is the same as that of the land lines. Germany's proposition was to make a low, uniform rate by the land lines, and to allow the cables to charge something in excess. The effect of this, if adopted, would have been that the great bulk of the traffic now passing over the cables would have been diverted to the Government land lines, and the public, as well as the European States, would lose the advantage, which it now possesses, of having any number of routes open for the transmission of telegrams at equal rates. The representatives of the companies urged this strongly on the State delegates to the Conference, and the position was recognised, the uniformity of tariff was abandoned, and new rates were arranged, all of them something, and in some cases very considerably, less than those now in force, applicable both to the cables and the land lines.

The cumbersome "grundtax," or initial charge of five words, which the English and French public know nothing about, but which is general in other countries throughout the Continent, was abolished, and the word rate pure and simple agreed to.

The Conference was so much engaged on the question of tariffs that very few changes were made in the regulations which govern the telegraph service; these changes may be summed up in a few words.

At the present time code telegrams exchanged between two places in Europe must be composed of one language; after the 1st of July next they may be written in any one or more of the eight languages which are now admitted for telegrams exchanged with places out of Europe. The present rules of counting and charging extra European telegrams were not altered, but the Conference decided to strengthen the hands of the administrations in exercising their right to demand the production of the code books used by merchants in order to verify the authenticity of the words employed, many firms being accustomed to use irregular combinations which give great trouble to transmit, and deprive the administrations of a considerable portion of their legitimate revenue.

The Conference also made a new regulation, giving greater facilities for refunding the charges for service telegrams sent to obtain the repetition of words unintelligible or supposed to be mutilated in transmission.

It decreed that, unless otherwise directed, all telegrams should be sent by the cheapest route; but the Conference did

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not withdraw the privilege of sending telegrams by any special route desired by the sender.

In extra European telegrams, at the present time, words containing more than ten letters are charged for as two words. This becomes a hardship when the sender wishes to address his telegram to a place requiring more than ten letters to express it, such as "Buenosayres," "Constantinople," or "Pietermaritzburg." A new regulation was introduced allowing the name of the office or country of destination to be counted as one word, irrespective of the number of letters employed to express it.

The Conference supplemented the present regulations with respect to "urgent telegrams," a class of telegrams widely used on the Continent, but unknown in this country. Urgent telegrams are those which take precedence of all others, except State telegrams. They are especially cared for, and in return for this they bear a tariff equal to three times that of an ordinary message.

The labours of the Conference were completed by numerous minor matters of detail, important in themselves, but not worth enumeration in this place.

The President was able to notify the adhesion to the convention of the colonies of Tasmania, Senegal, and Tunis, making a total of forty Sovereign Administrations which accept the rules adopted at Berlin.

The Eastern and the Indo-European Telegraph Companies notified their intention of meeting the wishes of the Indian Government by reducing the rate to India from 4s. 7d. to 4s. per word after the 1st July. The Eastern Extension Telegraph Company announced to the Conference that it would lower its rates to China and Australia, provided that other administrations concerned also reduced their charges; the exact amount of the reduction in both cases is not yet determined, but it will be either 2 francs or 2s. per word. There will also, after 1st July, 1886, be some modification in the rates to Cochin-China, Tonkin, and Japan.

The telephonic system of London is not one whit better than it was twelve months since, and we would commend to the careful consideration of all interested in the matter the following list showing the operations of the National Company and the prices charged to subscribers. We congratulate the National Company on its enterprise, but imagine there still remains much room for development and improvement. The statistics given are correct up to the 31st day of October, 1885:—

Name of Centre.	Annual Subscription.	No. of Lines.		Name of Centre.	Annual Subscription.	No. of Lines.	
		Exchange	Private.			Exchange	Private.
	£				£		
Dundee	10	1030	37	Whitehaven..	10	23	—
Perth	10	128	—	Carlisle	10	27	1
Forfar	10	8	1	Bradford	15	478	34
Arbroath	10	8	1	Leeds	15	388	76
Aberdeen	10	463	29	Huddersfield .	15	78	49
Inverness......	10	73	2	Dewsbury ...	15	105	19
Kirkcaldy ...	10	41	6	Halifax	10	52	17
Edinburgh ...	15	331	69	Wakefield ...	15	15	16
Glasgow	20	998	209	Sheffield	10	26	2
Greenock	14	109	14	Scarboro'	12	20	3
Paisley.........	15	41	7	Birmingham .	15	373	83
Dumbarton ...	15	7	38	Wolverhmptn	12	50	32
Coatbridge ...	15	15	—	Wednesbury..	12	49	48
Hamilton ...	15	6	—	Brierley Hill .	12	2	6
Belfast	15	375	130	Kidderminstr.	10	20	—
Maryport ...	10	2	1	Hanley	12	42	10
Workington..	10	12	1	Nottingham .	15	254	54

Total Centres = 34. Total Exchange Lines = 5,649. Total Private Lines = 995

The Company's trunk lines exist between the following towns:—

Dundee	and	Perth	Bradford	and	Halifax
Dundee	and	Forfar	Bradford	and	Dewsbury
Dundee	and	Arbroath	Leeds	and	Dewsbury
Edinburgh	and	Glasgow	Leeds	and	Huddersfield
Glasgow	and	Greenock	Leeds	and	Wakefield
Glasgow	and	Paisley	Dewsbury	and	Huddersfield
Glasgow	and	Dumbarton	Halifax	and	Huddersfield
Glasgow	and	Coatbridge	Birmingham	and	Wolverhampton
Glasgow	and	Hamilton	Birmingham	and	Wednesbury
Maryport	and	Workington	Wolverhampton	and	Wednesbury
Maryport	and	Whitehaven	Nottingham	and	Loughboro'
Bradford	and	Leeds	Sheffield	to	Leeds
Bradford	and	Huddersfield			Total number trunk lines = 25.

Passing from the general to the special, we may notice that during the year the second electrical railway has been opened. This railway is at Blackpool, and has been constructed upon the plans of Mr. Holroyd Smith. The time during which it has been in work is too short to give any real proof as to whether it will be a successful venture or not, and we must repeat, in season and out of season, that tramways or railways are not built for philanthropic purposes, or to prove scientific theories, but to pay the shareholders. The enterprise at Blackpool will be watched with a great deal of interest, and it is to be hoped the annual balance-sheet will be framed to give information, and not to hide from the general public the real state of affairs. If success attends this venture, other sea-side towns will follow the good example.

The electric railway at Brighton—the first of the kind in England—has to be looked upon in a somewhat different manner. It was initiated and has been carried out principally by the enterprise and energy of one man—Mr. Volk. This railway has been running throughout the whole year, and we have often referred to it in our columns.

There is not much to add to our previous remarks upon this most successful venture, except to say that it has continued running throughout the year, and carried a heavy traffic without hitch or delay. The motors in the cars have required no repairs beyond truing up the commutators occasionally; the generating dynamos have each required to be fitted with a new commutator. The severe work to which the plant is subjected proves that electric locomotion can be thoroughly depended upon to carry a heavy traffic, the cars here running incessantly for a period of twelve hours per day, and having a recorded mileage of 31,200 miles per annum.

The cost of traction is (using a gas engine) a fraction over 2d. per car mile, and the average earnings 1s. 3d. per mile. Of course the tramway has been constructed and carried out under exceptional circumstances, but the authorities of Brighton are to be highly praised for the spirited manner in which they have supported the enterprise, and enabled their townsman to show what really can be done in this direction.

On electric light work our space permits us to touch but very briefly in this issue, and therefore we take the work of the oldest firm, that of Siemens Brothers and Co., to start with:—

During the past year the various works carried out by this firm have in general been of the usual kind. In the electric light department, at the Inventories, the contract for the illumination of the grounds was given to Messrs. Siemens Brothers and Co., for which nearly 10,000 incandescent lamps were required. These were divided into twenty-three circuits, each of eight parallels of lamps, the twenty-three circuits being coupled up so as to form eight sections, the whole being controlled from a central switch room under the clock. For supplying the current required to work these lamps, three

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Siemens self-regulating dynamos were provided, of the largest size ever made of that construction. These dynamos were of such power that two of them were capable of producing even more than the necessary current, the third being spare. During the whole of the time this installation (which may be considered as the most extensive of its kind yet carried out) was in work there was not the slightest hitch or breakdown in any of the electrical plant or apparatus, and we believe the result gave universal satisfaction to the large numbers of the public who visited the Exhibition. Contracts have been carried out to completely fit with electric light the following men-of-war for the Admiralty: — The "Imperieuse," "Collingwood," "Edinburgh," "Warspite," and "Rodney," and search lights for a large number of other ships and gunboats have also been supplied to order of the Government. A number of ships of the principal passenger lines of steamers have been fitted with the electric light. In cable work, Messrs. Siemens have completed the system of cables for the Mackay-Bennett Company, commenced in 1884 by the laying of a section from Waterville, in Ireland, to Havre, in France, and another from Waterville to Weston-super-Mare, near Bristol, this being the nearest point to London to which any Atlantic cable has, as yet, been brought; while on the other side of the Atlantic the cable is carried direct into the offices of the company, in the City of New York, without any intermediate land line. The Mackay-Bennett cables, therefore, now form a system consisting of two main cables from Waterville to America (one landing at Rockport, in Massachusetts, and the other at the office in New York), and branch cables from Waterville, one to Havre and the other to Weston-super-Mare. In addition to this work various repairs of cables have been carried out in the Atlantic, and we may mention the interesting fact that five repairs, all of them in deep water, from 2,000 to 2,600 fathoms, have been effected with the ss. "Faraday" within a period of twelve months, in addition to the work of laying those cables to which we have referred above.

Writing this portion of our notice for 1885 on its closing evening, we have great pleasure in wishing our subscribers and friends a Happy and Prosperous New Year for 1886.

CORRESPONDENCE.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The question raised by the narrative of the electric boy may be of much importance. If, as seems capable of demonstration, all the muscles of the human body depend upon the healthy existence of a permanent electric current, and each pair of muscles may be exerted without interference with the current operating among other muscles, we have much to learn which the existence of a so-called electric boy might enable us to elucidate. Some time time ago I saw some experiments in this direction conducted by Prof. Dewar. He not only showed, by means of a galvanometer, that when he exerted the muscle of one arm the needle deflected to the right, and when the corresponding muscle of the other arm was exerted it deflected to the left, but so delicate a pair of muscles as regulated the sight of each eye was shown with equal clearness to be similarly dependent upon a permanent electric current. This he did by surrounding the eye with a simple solution, and connecting it with the galvanometer, which immediately indicated the movement of the muscles, directing the sight to the right or left by the deflection of the needle in contrary directions. The effect of the displacement of the current by one set of muscles in no way affected the current associated with any other muscles, and although I am not at present aware of any way in which electrical research could be directed to prove the fact, I have no doubt so delicate a point as the interdependence between accommodation and convergence in vision would depend upon separate sets of muscles having separate permanent electric currents. Other interesting questions to be solved are:—The possibility of certain permanent currents existing in the human body being united without endangering life. The total strength of the permanent currents operating the human body. The possibility of determining the relative difference of strength, if any, in health and disease, in youth and age. The source of the periodical removal of the currents; if in the brain and sleep, by what special nerves or otherwise is the renewal supplied? Inquiries of this nature being assisted by the intelligence of the subject of the inquiry might lead to some comprehension of the mystery of the currents in the earth. The general utilisation of electricity would probably be much advanced by the success of such inquiries.—Yours, &c.,

RICHARD HERRING.

27, St. Mary's-road, Canonbury, 28th Dec., 1885.

NITRATE IN BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I shall be greatly obliged if you can give me any information on the following:—

1. Taking nitrate of soda, what are the correct proportions of water and sulphuric acid for depolarising solution?

2. Should the water be saturated with the nitrate before the sulphuric is added?

3. Given a saturated solution of nitrate of soda, is it capable of dissolving and holding in solution a further quantity of nitrate of potash and bichromate of potash, and if so would it necessitate an extra quantity of sulphuric acid?—Yours, &c.,

ATOM.

BICHROMATE OF POTASH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can you inform me through *The Electrician* of a firm which manufactures bichromate of potash, and also of a firm from whom I can obtain, wholesale, rolled zinc rods ¾in. diameter and two or three yards long, for batteries?

I have a bichromate battery for lighting up my house, in which I use old carbons which have been used in Siemens and Brush arc lamps. The battery works well; but do you think it would work any better with proper battery carbons?

I am using incandescent lamps for fifteen volts and five volts; for the former I have for the main wires No. 14 and from the main to the lamps No. 22. For the latter I have No. 18 for main, and No. 24 from main to lamps. Am I using the proper numbers of wires? If you can give me the above information I shall be obliged.—Yours, &c.,

F. ISSELS.

THE WINDING OF VOLTMETERS.*

BY PROFESSORS W. E. AYRTON, F.R.S., AND JOHN PERRY, F.R.S.

I. The use of voltmeters for measuring the potential difference existing between the mains in electric light circuits, and for enabling us to maintain this potential difference constant, is so wide in its possible application, that it is unnecessary to dwell on the importance of voltmeters giving accurate indications. Indeed, the sensibility of an incandescent lamp to changes in the potential difference at its terminals is so great (the light, as we have shown in a previous communication to this society,† being in many cases proportional to the cube of the potential difference minus a constant) that it is necessary that voltmeters should record with great accuracy the potential difference, as well as quickly indicate any changes that may from time to time take place in this potential difference.

* Paper read before the Physical Society.

† The most economical potential difference to employ with incandescent lamps.—*Proc.* Phy. Soc., Vol. VII., page 40.

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It is, therefore, desirable to consider what are the most important errors in commercial voltmeters as at present constructed, and how these errors may be practically diminished or altogether removed. They are :—

1. An error arising from the sensibility of the voltmeter varying with its resistance, and therefore with its temperature. This change of temperature is due partly to the variation of the temperature of the room and partly to the coils of the instrument becoming heated by the passage of the current through them.

2. An error arising from the sensibility of the instrument being temporarily varied by external magnetic disturbance.

3. An error arising from certain types of voltmeters altering in sensibility, so that their constants vary from time to time.

4. An error arising from the volt standards employed by different makers of voltmeters differing several per cent. from one another.

The variation in the resistance of a voltmeter produced by changes of temperature of the room can, of course, be made very small by winding the instrument with German silver wire, or better with platinum silver, or best of all with wire made of platinoid, or it may be made absolutely nought by using an outside resistance of carbon; or, lastly, if the voltmeter be simply wound with copper wire, this error, although large, can be accurately allowed for if the temperature of the voltmeter be known. But the error arising from the heating of the voltmeter by the passage of the current through it is much more difficult to allow for, as this rise of temperature of the instrument will be unknown. Hence it is important to reduce this error to a minimum, and it does not at all follow that the employment of German silver wire or even platinoid wire will affect this result; indeed, we have already given, in a previous communication made to this society*, general reasons showing that German silver is undesirable to be used in the winding of voltmeters. When, however, the diameter of the coil of the instrument exceeds a certain limit it would appear that German silver wire might be better for the outer coils, hence the following investigation has been made for the purpose of ascertaining whether in an instrument of the size of our solenoid or long range voltmeter any portion of the coil should be wound with German silver wire, and if so, how large a portion; also what should be the law of variation of sectional area of the wire with the diameter of the convolution in which it is wound, so that the heating error produced by the passage of the current through the voltmeter shall be a minimum.

Although the dimensions of the instrument adopted in the following investigation are those of this special form of voltmeter, the mode of considering the problem will apply equally well to any other galvanometer used as a voltmeter, or to the fine wire coil of an ohm-meter, power-meter, and erg-meter, or, indeed, in any case where it is desired to produce a given magnetic effect with a minimum error due to heating. It is only necessary to consider the case of a cylindrical coil of internal radius r_0 and external r_1 and length l, as it is easy to extend our reasoning to a coil of any other shape and dimensions.

II. At a place in the coil at a distance, r, from the axis let the cross section of the wire be x, let ρ be the specific resistance of the material, and γ the rate at which ρ increases with temperature, x, ρ, and γ being functions of r. For simplicity of calculation we shall neglect the volume of the insulating material. Let one spire of radius r produce a magnetic effect of the amount

$$K\,C\,r^d \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

C being the current, and d having in almost all instruments a value which lies between the limits -1 and 0. Also let

$$x = x_0\, r^a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$\rho = \rho_0\, r^b \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$\rho\,\gamma = \rho_0\,\gamma_0\, r^c \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

In a layer of wire of thickness δr there are $\frac{l\,\delta r}{x}$ spires of wire, and the resistance of the layer is

$$\frac{2\pi r \rho l}{x^2}\delta r, \text{ or } \frac{2\pi r \rho_0 r^b l}{x_0^2 r^{2a}}\delta r, \text{ or } \frac{2\pi \rho_0 l r^{1+b-2a}}{x_0^2}\delta r,$$

so that the whole resistance of the coil is evidently

$$R = \frac{2\pi\rho_0 l}{m x_0^2}(r_1^m - r_0^m) \text{ if } m = 2 + b - 2a \quad . \quad . \quad . \quad . \quad (5)$$

The magnetic effect of the spires in the thickness δr is

$$K\,C\,r^d\, l\frac{\delta r}{x}, \text{ or } \frac{K\,C\,l}{x_0} r^{d-a}\,\delta r,$$

so that the whole magnetic effect of the coil is

$$M = \frac{K\,C\,l}{x_0 n}(r_1^n - r_0^n) \text{ if } n = d - a + 1 \quad . \quad . \quad . \quad . \quad (6)$$

We shall now assume that we can, by introducing thin strips of copper among the windings, give the same ease of cooling to unit volume of the wire everywhere; that is, after the current has flowed for some time, that the increase of temperature at any point is proportional to the rate at which current heat is produced per unit volume. Now,

$$C^2\frac{2\pi\rho_0}{x_0^2} r^{1+b-2a}\, l\,\delta r, \text{ or } C^2\frac{\rho_0}{x_0^2} r^{b-2a} \,.\, 2\pi r l \,\delta r$$

is the rate at which heat is produced in a layer of thickness δr.

This rate is $\frac{\rho_0}{x_0^2} r^{b-2a}$ times the volume of the layer. Therefore, the rate at which heat is produced *per unit volume* is $C^2\frac{\rho_0}{x_0^2} r^{b-2a}$; hence, by hypothesis, the increase of temperature is proportional to $C^2\frac{\rho_0}{x_0^2} r^{b-2a}$.

The increase of resistance of this layer is the resistance of the layer multiplied by γ times the increase of temperature, and is therefore proportional to

$$\frac{2\pi\rho_0}{x_0^2}\, l\, r^{1+b-2a}\,\delta r \,.\, \gamma \,.\, \frac{C^2\rho_0}{x_0^2} r^{b-2a},$$

$$\text{or to } \gamma\frac{C^2\rho_0^2}{x_0^4} r^{1+2b-4a} \text{ where } \gamma = \gamma_0 r^{c-b},$$

and the whole increase of resistance is proportional to

$$\int_{r_0}^{r_1} \gamma_0 C^2 \frac{\rho_0^2}{x_0^4} r^{1+b+c-4a}\, d r,$$

$$\text{or } \gamma_0 C^2 \frac{\rho_0^2}{p\, x_0^4}(r_1^p - r_0^p), \text{ if } p = 2 + b - 4a + c. \quad . \quad (7)$$

so that the fractional change of resistance is proportional to

$$\frac{\gamma_0 C^2 \rho_0^2}{R\, x_0^4\, p}(r_1^p - r_0^p) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Now, regarding M as constant, and substituting for C and R from (6) (5) and (8), we observe that the fractional change of resistance due to heating is proportional to

$$\gamma_0\rho_0 \cdot \frac{n^2}{(r_1^n - r_0^n)^2} \cdot \frac{m}{r_1^m - r_0^m} \cdot \frac{r_1^p - r_0^p}{p} \quad . \quad . \quad (9)$$

and it is required to find the values of a, b, and c, for which this expression is a minimum.

III. It may be seen that the error (9) is less as $\gamma_0\,\rho_0$ becomes less, therefore $\gamma_0\,\rho_0$ should be made as small as possible so that *when wires of two metals, as for example copper and German silver, are employed, the wire for which $\gamma\,\rho$ has the least value, that is the copper, should be used for the inner winding.* It is, however, when we consider the waste of electric energy in the coil that the great objection to the use of German silver for the internal winding becomes still more striking, for the rate of production of heat in the coil is proportional to $C^2 R$ which, from (6) and (5), equals

$$\frac{x_0^2 n^2 M^2}{K^2 l^2 (r_1^n - r_0^n)} \times \frac{2\pi\rho_0 l}{m\, x_0^2}(r_1^m - r_0^m).$$

* "Direct Reading Electro-Measuring Instruments, and a Non-Sparking Key."—*Proc.* Phy. Soc., Vol. VI., page 69.

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Hence to produce the same magnetic effect M in a coil of given length l, the rate of production of heat is proportional to

$$\frac{n^2}{(r_1^n - r_0^n)^2} \times \frac{r_1^m - r_0^m}{m} \rho_0 \quad . \quad . \quad . \quad (10)$$

Consequently the rate of wasting electrical energy in heat will be thirteen times as great if German silver wire be used as it will be if copper is used, when a given angular deflection is produced, no matter what be the gauge of wire employed—that is, whether the voltmeter be wound to measure a maximum potential difference of 50 or of 500 volts.

Eliminating r from (3) and (4) it follows that

$$\left(\frac{\gamma \rho}{\gamma_0 \rho_0}\right)^{\frac{1}{c}} = \left(\frac{\rho}{\rho_0}\right)^{\frac{1}{b}} \quad . \quad . \quad . \quad . \quad (11)$$

where b may have any arbitrary value. Hence, if there is a regular change possible in the value of $\gamma \rho$, such as is given in (4), we must have

$$c = \mathrm{P} b$$

where P is some constant. Equation (11) therefore becomes

$$\frac{\gamma \rho}{\gamma_0 \rho_0} = \left(\frac{\rho}{\rho_0}\right)^{\mathrm{P}} \quad . \quad . \quad . \quad . \quad . \quad (12)$$

If, therefore, our wire in the inside of the coil is of copper, and at the outside of German silver,

$$\gamma \rho = \frac{13}{9} \gamma_0 \rho_0,$$

or

$$\rho = 13 \rho_0.$$

Hence from (11) $\frac{13}{9} = 13^{\mathrm{P}}$,

or $\mathrm{P} = 0{\cdot}143$,

and $c = 0{\cdot}143 b \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$

It is certain that generally the relationship between γ and ρ cannot be of the simple character here assumed, but inasmuch as our results are only applied in cases where the windings are either of German silver or of copper, or of the two together—and in these cases the expressions used are quite correct—there is no practical objection to the use of such a law. The law is very nearly the same as the assumption that a wire of any material lying electrically between German silver and copper is made up of wires of German silver and copper.

Since from (7) $p = 2 + b - 4a + c$,

it follows, using (13), that $p = 2 + 1{\cdot}143 b - 4a \quad . \quad . \quad . \quad (14)$

and the values of m and n are given respectively in terms of a, b, and d in (5) and (6), and are

$$m = 2 + b - 2a \quad . \quad . \quad . \quad . \quad . \quad (14)$$

$$n = d - a + 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

In our solenoid voltmeter r_0 equals 1, r_1 equals 8, and d equals − 1, and since the greatest value of ρ is $13\rho_0$, it follows that r^b cannot be greater than 13; but b is a constant, and the greatest value of r is 8, therefore b must be less than 2. From (14), since b is always small, we see after a has reached a certain large value that p, m, and n increase numerically as a increases, and are positive when a is negative, and *vice versâ*, also that, finally, p equals $2m$, or equals $4n$.

Substituting the values for r_0 and r_1 the error (9) may be written

$$\frac{\gamma_0 \rho_0 \left(\frac{n}{8^n - 1}\right)^2 \left(\frac{m}{8^m - 1}\right)}{\frac{p}{8^p - 1}}$$

and it may be seen by inspection that each of the factors of which it is composed is always positive, whether m, n, and p be positive or negative. Therefore the error is always positive. For large values of m, n, and p the error may be written

$$\frac{\left(\frac{n}{8^n - 1}\right)\left(\frac{2^n}{8^{2n} - 1}\right)}{\frac{4^n}{8^{4n} - 1}} \text{ which equals } \frac{\left(\frac{n}{8^n - 1}\right)^2}{\frac{2}{8^{2n} + 1}}, \text{ or } \frac{n^2 (8^{2n} + 1)}{8^{2n} + 1 - 2 \times 8^n}$$

This expression is always greater than n^2, whether n be positive or negative, and is therefore very great, since n is great. Consequently, for large positive or negative values of m, n, and p the error (9) becomes very great, and therefore it can have no maximum. The values of a and b, therefore, found from equating to nought its differential coefficients with respect to a and to b, will give a minimum value of this error. And the error will be a minimum when its logarithm is a minimum. Now, taking its logarithm, putting r_0 equal to 1, and r_1 equal to 8, differentiating with regard to a and b respectively, and equating to zero, we arrive at the equations

$$\phi(n) - 0{\cdot}857 \phi(p) = 0 \quad . \quad . \quad . \quad . \quad (15)$$

$$\phi(m) - 1{\cdot}143 \phi(p) = 0 \quad . \quad . \quad . \quad . \quad (16)$$

where $$\phi(a) = \frac{\log \epsilon^8}{1 - 8^{-a}} - \frac{1}{a} \quad (17)$$

To assist in the solution of these three simultaneous equations, we calculated the following table :—

Table I.

a	$\phi(a)$
− 3	0·3293
− 2	0·4670
− 1	0·7029
0	1·0397
1	1·3764
2	1·6124
3	1·7502
4·5	1·8474
10	1·9794
100	2·0694

and in order to solve these three equations we used the following artifice :—A curve was first plotted on squared paper with $\phi(a)$ as ordinate, and a as abscissa, and by means of this curve for any value of $\phi(a)$ given we could at once find a approximately.

Table II. was then arrived at in the following way :—A value of p was chosen, and $\phi(p)$ written down. Then, since $0{\cdot}857 \phi(p)$ is equal to $\phi(n)$ by (15), n was known from this by the curve for $\phi(a)$; m was next found in the same way from (16). Thus columns 1 and 4 in Table II. contain values of p and n which satisfy (15), and which were obtained in this way, while in columns 1 and 6 we have values of p and m which satisfy (16).

Table II.

p	$\phi(p)$	$0{\cdot}857 \phi(p)$ or $\phi(n)$	n	$1{\cdot}143 \phi(p)$ or $\phi(m)$	m
2	1·6124	1·381	1·03	1·842	4·35
1	1·3764	1·18	0·39	1·572	1·78
0	1·0397	0·8913	− 0·425	1·189	0·425
− 1	0·70295	0·6026	− 1·370	0·8035	− 0·69
− 2	0·467	0·4002	− 2·38	0·5337	− 1·69

Now, first using the pair of columns 1 and 4, we chose corresponding values of p and n, say 2 and 1·03; then, since

from (14) $2 = 2 + 1{\cdot}143 b - 4a$,

and $1{\cdot}03 = d - a + 1$

we could calculate a pair of values for a and b which satisfied (14) and (15), since d was assumed to be known. Next, taking another pair of values of p and n from Table II., another pair of values of a and b was calculated, and so on.

Plotting these values of a and b as co-ordinates of points on squared paper we obtained the curve *sss* (Fig. 1)* the co-ordinates of every point of which are the values of a and b that satisfy (15). In the same way we drew the curve *ttt* for (16), and the co-ordinates of the point of intersection Z are the values of a and b which satisfy (15) and (16), and therefore make the error (9) a minimum.

Thus, for example, taking $d = -1$, as seems to be the case

* This and the two succeeding figures are only about one-twelfth of the size each way of the figures actually employed in the calculations.

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in our solenoid instrument, we find that, with some approximation to accuracy,

$$a = 0{\cdot}19 \quad \text{and} \quad b = -0{\cdot}82$$

for minimum error. But if we have used our material of least resistance for the inner winding, b cannot in practice be less than 0, for ρ cannot be less than ρ_0; and since r is never

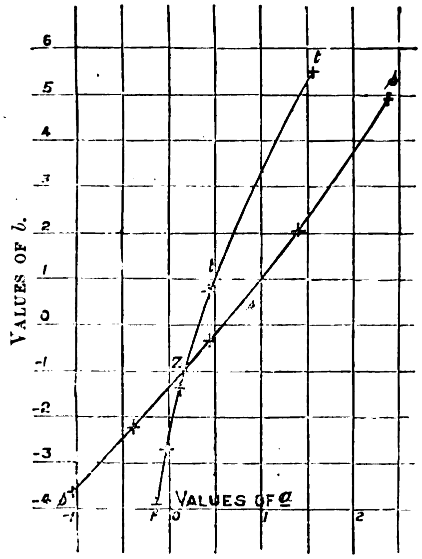

Fig. 1.

less than 1, ρ would be some fraction of ρ_0 if b were less than 0. Hence, in practice we find that b must equal 0—that is, *a less heating error is produced when all the wire is of copper than when we use German silver windings on the outside of the coil.*

(To be continued.)

DYNAMO TESTS.

It is well known to our readers that a series of dynamo tests were carried out at the Philadelphia Exhibition. The full report of these tests has just been issued by the Franklin Institute. All tests have a certain value, and although much has been said against the tests at the Philadelphia Exhibition, we do not hesitate to give the report almost verbatim, so that our readers can judge for themselves the exact value to be given to the figures. The sections preceding the commencement of our reprint are of no interest scientifically, and as our space is none too great, we have not given them.

Section III.—*Preliminary Tests.*

5. The resistance of the field magnet coils and of the armature coils will be measured as follows :—A strong current from a secondary battery shall be passed through these coils and amperemeter and sensitive voltameter used to determine current and fall of potential. The resistance will be determined from these measurements. As an additional precaution, a strip of German silver of known resistance shall have its fall of potential measured with the same current and instruments. These measurements shall be made before and after the tests, with the machine hot and cold.

Insulation Resistance.

6. Tests will be made of the insulation of the terminals of the machine from its metal bed plate. Tests will be made of the insulation resistance between the commutator and the axle.

7. It is understood between the parties that if any mechanical defect is observed, another machine may be substituted if the committee agree that such defect exists. The competitors shall have reasonable opportunity to obtain information of the progress of the tests, and to know the figures of each test for the object of ascertaining errors in time for correction. The observations made will be publicly posted before the machine is removed from the dynamometer.

Calibration of Instruments.

8. The constants of all instruments used shall be determined by at least two independent methods. The companies shall have opportunity to inspect and observe the methods used, and shall be furnished with the constants of the instruments immediately after they have been determined. All objections to the methods used will be received and acted upon as provided under Section IV., Article 17.

Section IV.

Quantitative Tests.

9. The dynamo to be tested will be run under full load for ten hours continuously, to see that all is in good working order before the tests begin.

10. For the actual test the machine shall be run and the temperatures of the pole pieces and armatures observed until a uniform temperature is reached.

11. When a uniform temperature for each load is reached, the measurements of power shall begin.

12. The machine will be tested on both live and dead resistances.

13. The machine will be tested on one-quarter, one-half, three-fourths, and full load. In the latter case, to be run at least five hours after a uniform temperature is reached.

14. Full measurements of friction and of energy expended in field will be made in each case.

Dynamometric Measurements.

15. The shaft of the dynamo will be directly attached to the end of the shaft of Tatham's dynamometer, by means of a universal joint coupling, and the horse-power used read from the dynamometer, unless the committee, for reason, shall decide otherwise.

Observations.

16. The observations on the dynamometer, current galvanometer, and potential galvanometer, and all other instruments, will be taken at synchronous intervals. The temperature of the room will be made as even as possible, and the temperature noted and necessary corrections made. The adjustment and oiling of machines shall be in the hands of the authorised expert for the company.

17. In case any objection be made, or difference of opinion should arise between the committee and the contestants, the unanimous vote of the committee shall be final. If, however, there be not a unanimous vote, the minority of the committee shall appoint one referee and the majority another; these two shall appoint a third referee. The decision of the majority of these referees shall be final.

In all determinations of efficiency of machines, measurement of potential shall be made (simultaneously with measurements of the current strength) at the binding posts of the machine, and at such other points of the circuit as will determine the total fall of potential, due to the resistance of the leads, connections and switches included in circuit with the instruments used for determining current strength. From these measurements, the loss shall be calculated and credited to the machine under trial.—(Signed) Francis R. Upton, United States Electric Lighting Company, per Edward Weston, electrician.

Fig. 1 gives the general arrangement of the apparatus. The test room, in which most of the instruments for electrical measurement were placed, was in about the middle of the exhibition building of the Franklin Institute. The dynamos, with the boiler and engine used in running them, were in a shed at one corner of the building; and the resistances for their external circuit—lamps and German silver strips—in a room inside the building and very near the shed.

The storage battery, tangent galvanometer for current calibrations, and galvanometer for measuring field currents, were in different parts of the building, far enough from the test room not to affect the instruments in it. The leads from the dynamos and storage battery and to the tangent galvanometer were of heavy, insulated copper cable. They were taken to the corner of the test house farthest from the instruments, and where they approached it the two parts of a circuit were

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twisted together, one of them being covered with rubber tubing as an additional precaution against leakage. Even with the heaviest currents (about 400 amperes) there was no effect on the instruments, and calibrations made both when the dynamos were and were not running, showed that any disturbance from currents in the leads had been avoided. Before any measurements were made, the insulation resistances between the leads themselves, and from the leads to the ground, were carefully tested and found in every case to be over fifty megohms; and measurements at intervals during the tests showed that they remained about the same.

Observations.

The power applied to the dynamos was measured by a Tatham dynamometer, while the electrical energy was calculated from observations of the potential at the terminals of the machine, the currents in the external circuit and field, and the resistance of the armature. The latter was measured by sending a current from a storage battery through the armature and observing the current in the circuit and fall of potential between the terminals of the machine. The dynamos were run both on lamps and dead resistance, the value of the latter serving as a rough check on the potential and current.

APPARATUS.

Storage Battery.—This was kindly furnished by Mr. Weston, and was used for all calibrations, measurements of armature resistance, &c. Seventeen cells in series were generally employed; they were placed on boards separated from the floor by porcelain insulators.

Tangent Galvanometer—This was used for calibrating the current galvanometer. It consisted of a single turn of a large-sized wire fastened on the edge of a wooden disc which was nailed against a square board frame. The ends of the wire were bent up parallel to each other and fastened by brass connectors to the leads. A correction due to the space between the ends of the turn was applied to the mean radius. The diameter, about two metres, was measured in different directions, and the mean taken in calculating the constant. There was a space cut in the middle of the wooden frame, with a shelf for the compass and needle. After the needle was adjusted to the centre and levelled, plumb lines and pointers were arranged so that any warping or change of level could be at once detected. The value of H was determined by a magnetometer of the coast survey pattern with detached theodolite, it was found to be ·1938, and the constant of the galvanometer 31·088 amperes.

External Resistances of Dynamos.—The "dead" resistances for the external circuit of the dynamos were made of German silver strips 1¼in. wide by about ·01in. thick. They were eight in number, each wound on a frame about 3ft. square by 10ft. high, made of four wooden uprights with pieces framed across at the top and bottom. Porcelain insulators were fastened horizontally to the cross pieces and the resistances passed under one of the bottom insulators, over one at the top, to the bottom again, &c. Heavy copper wires were hard soldered to the ends of the strips and taken to the switch-board. The resistances were adjusted by cutting out part of the strip by a short length of German silver with clamps at the ends, which could be shifted to cut out as many of the turns as was desired. The coils were adjusted by means of a calibrated bridge, to 2·400 ohms at 20° C. There was a good air circulation in the room, and fifty amperes could be carried by each coil. In the same room with the German silver resistances were the racks for the incandescent lamps used for "live" resistances.

Switch-board.—Two troughs about 2½ft. long and 1½in. wide, and 10in. apart, were cut in a heavy block of wood. Between them were bored two rows of eight holes each, and into these were fitted glass insulators turned upside down to serve as mercury cups. The wood was soaked in boiling paraffin, and melted paraffin poured between the cups and allowed to harden. The distance between the troughs and the middle of the nearest row of cups was three and a half inches; between the two rows, and the cups in each row, three inches. The cups and troughs were filled with mercury, heavy amalgamated copper rods in the latter serving to increase the conductivity. The resistances were brought to opposite cups in the two rows. The dynamo circuit was from one terminal of the machine to an ordinary Edison switch, by which the current could be made or broken, to one of the troughs, through the resistance to the other trough, to the test house, passing through the fixed resistance for current measurement there, back by the other lead to the dynamo. Connections at the switchboard were made by thick U-shaped copper rods, with a stretch of three and one half inches. The resistances could be readily arranged in any desired way, with little or no chance of causing accident by making mistakes. The insulation between the troughs and the cups and the troughs themselves was practically perfect.

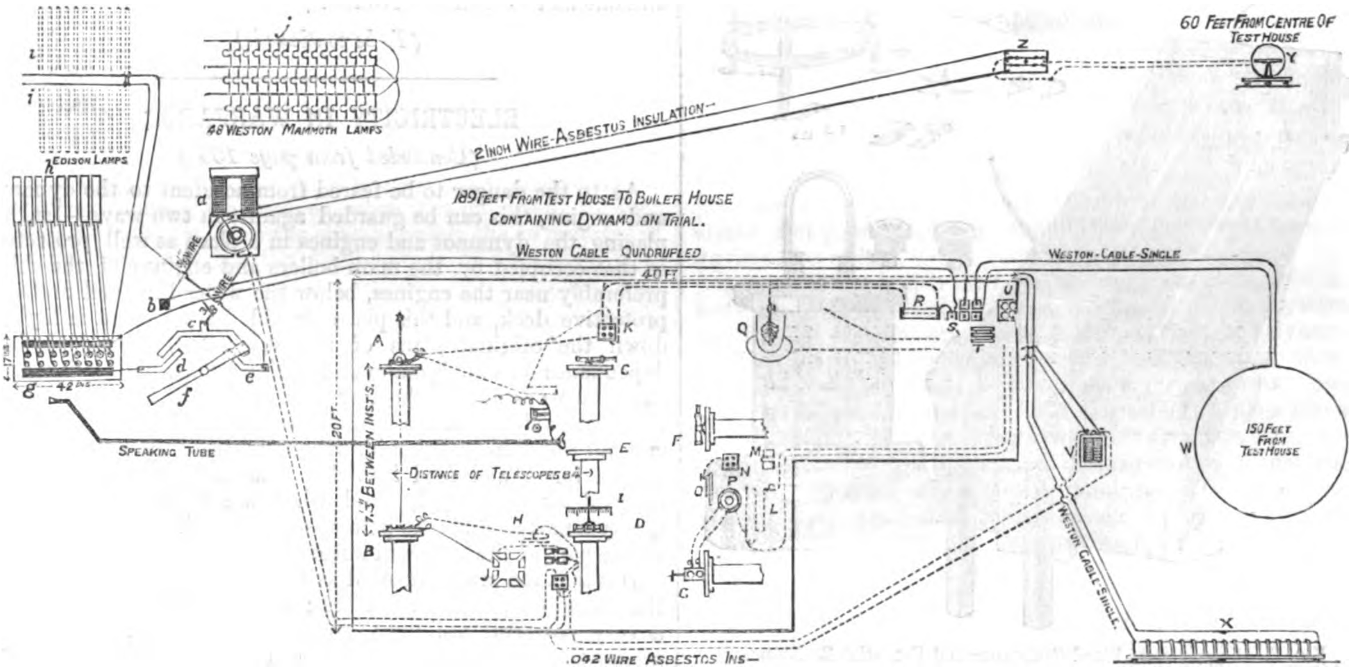

Fig. 1.—Arrangement of the Apparatus in the Test Room.

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Field Galvanometer.—The current in the field of the dynamos was measured by a tangent galvanometer of the Helmholtz type, the coils being each a single turn of large-sized wire. It was calibrated at the same time as the current galvanometer, being reversed as often as possible, and the same end of the needle read on each side of the zero mark.

Wheatstone Bridge.—For measuring resistances that could not be taken to the Johns Hopkins University, a resistance box, with a bridge attachment by Elliott, of London, was used, with a Thomson astatic mirror galvanometer. The box was standardised, as described below.

Calorimeter.—The calorimeter is shown below in Fig. 2. This was used for calibrating both the potential and current galvanometers; it was made of copper, was cylindrical in shape, about 8in. in diameter by 10in. in height, and held about eighteen pounds of water. The cover was screwed to a flange on the cylinder, the joint being water-tight; in it were holes with raised flanges around them, for the terminals of the coil and the thermometer. For stirring, a shaft, working in a bearing on the bottom of the cylinder and passing through the cover, had on it five paddles

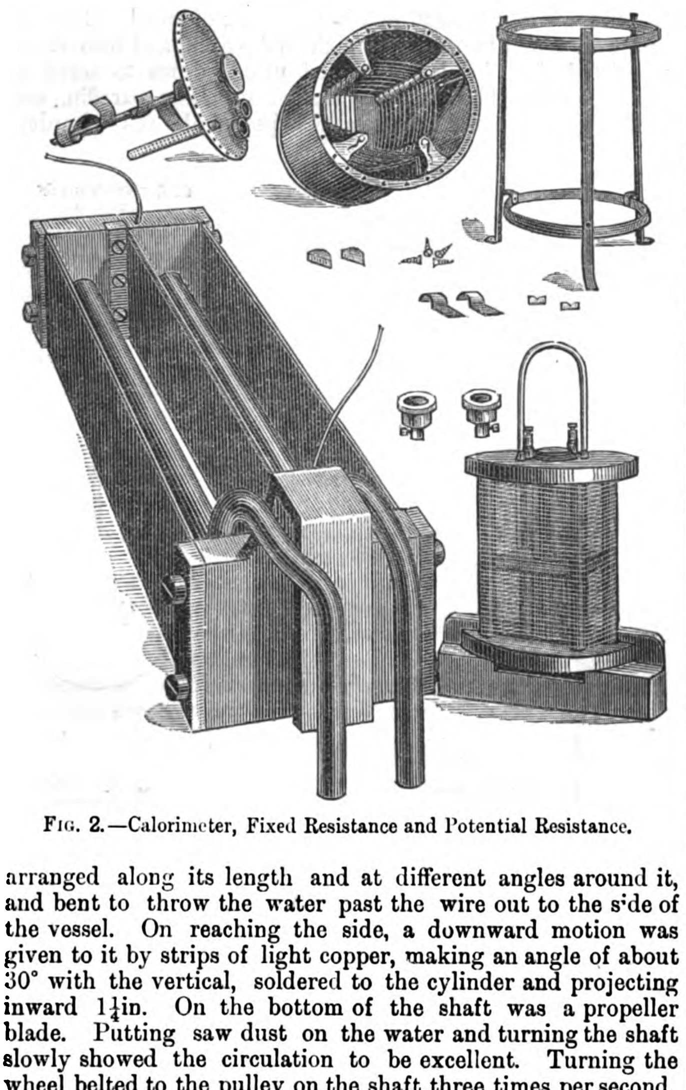

Fig. 2.—Calorimeter, Fixed Resistance and Potential Resistance.

arranged along its length and at different angles around it, and bent to throw the water past the wire out to the side of the vessel. On reaching the side, a downward motion was given to it by strips of light copper, making an angle of about 30° with the vertical, soldered to the cylinder and projecting inward $1\frac{1}{4}$in. On the bottom of the shaft was a propeller blade. Putting saw dust on the water and turning the shaft slowly showed the circulation to be excellent. Turning the wheel belted to the pulley on the shaft three times per second, raised the temperature of the calorimeter ·02° C. in five minutes. In the later experiments it was only turned once per second, so the error from this correction must have been small. In the first three experiments, copper wire of about 1·3 ohms resistance was used; in the last two platinum-silver wire of 1·1 ohms. The coil was held in the cylinder as follows:—At equal distances around the cylinder, at the top and bottom, were soldered pieces of copper projecting inward, with clamps at their ends. The wire was wound on glass rods held in a light framework; the whole was placed in the cylinder, the rods clamped in place and the framework cut away, leaving a clear space for the stirring arrangement. The terminals were small copper cups, thoroughly amalgamated and partly filled with mercury. They were surrounded by a rim of ebonite and wedged in their places in the cover. The calorimeter fitted in a light iron frame, from which it was separated by small blocks of ebonite. The whole was surrounded by a tin cylinder fitting closely on the shelf to which the frame was fastened, so there was no draught past the cylinder.

Balances.—Two balances were used, one for weighing the calorimeter, the other in voltameter work. The former could weigh up to thirty pounds and was very sensitive. The latter was an excellent analytical balance. Both were by Trœmner, of Philadelphia, and the weights were compared with standards in his possession.

Thermometers.—The thermometers generally used were by Green, of New York. They were divided into degrees and tenths, and were compared at the Johns Hopkins University with one of the standards there, the apparatus used in the comparison being that described by Prof. Rowland, in his "Determination of the Mechanical Equivalent of Heat."* For the last two calorimeter experiments, a thermometer by Hicks, of London, was used. It was graduated to centimetres and millimetres, and was one of those used by Mr. Leibig, in his work "On the Variation of the Specific Heat of Water."†

Potential and Current Galvanometers.—These will be described under measurements of potential and current. They, with the other instruments in the test house, rested on stone slabs, cemented on the top of heavy wooden posts, sunk about two and one-half feet in the ground.

(To be continued.)

ELECTRICITY IN WARFARE.‡

(Concluded from page 135.)

As to the danger to be feared from accident to the dynamo and engine, this can be guarded against in two ways—1st, by placing the dynamos and engines in a place as well protected as that occupied by the main boilers and engines of the ship, preferably near the engines, below the water line, and under a protective deck, and this place should be provided in laying down the original plans of the ship; 2nd, by not placing dependence on one dynamo and engine alone, but by dividing the total work among three or four, so that in case of accident to one the ship will have the benefit of all the others. To this end, all the dynamos should, of course, be of the same electromotive force, and feed into the same mains, from which all lamps draw their supply, and which are fed by feeders from the dynamos at different points, so that accident to the mains at one part of the ship will affect that part only.

But it is the arc light, used as what is called a search light, that is most valuable in warfare; a search light being simply a very powerful arc light, so arranged with a catadioptric mirror that it throws out a very concentrated beam of light, and so mounted that this light can be cast in any desired direction, and made to illuminate any locality which it is desired to inspect. I believe the first use made of search lights was in the siege of Paris in the Franco-Prussian war, when the French employed them to discover the operations of the besieging army at night. Their value, from a military point of view, was so evident that other nations took the hint and introduced them into their military and naval services. Since then their use has been extending, more probably for ship use than for use on shore, though they are also employed considerably in forts guarding the approach to harbours, to watch for the approach of hostile fleets, torpedo boats, or countermining expeditions at night.

For the use of an army in the field search lights are mounted on suitable waggons, together with portable boilers and engines, so that they can be taken on the march, moved to any part of the field, the top of a hill for instance, and

* *Proceedings* of the American Academy of Arts and Science, 1880.
† *American Journal of Science*, July, 1883.
‡ Lecture delivered before the Franklin Institute, November 13, 1885, by Lieut. B. A. Fiske, U.S. Navy.

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employed at night whenever desired. It is clear that a search light might often be very useful in doing such work as searching for wounded after a battle, examining the nature of the ground in a comparatively unknown country, watching the enemy when a surprise might be anticipated, guarding against a sortie from a beleagured fort or city, &c., on many occasions, in fact, when the darkness of the night might be a hindrance to the operations of an army or an element of insecurity. On board men-of-war the principal use of the search light has been in watching for the attack of torpedo boats; but the experiments in Bantry Bay last July showed that it was often useful in detecting the approach of hostile ships, in aiding the sighting of guns at night by bringing the target out clearly, and in embarassing the operations of a torpedo boat or ship in trying to force a passage up a channel, by dazzling the eyes of the enemy one instant and leaving them in total darkness the next. It was related that in Africa some three years ago an attack on a fort was frustrated by a single search light. The barbarians advanced to the assault brave and determined, under cover of darkness, but were suddenly terrified by finding themselves enveloped in an awful and miraculous light which turned night into day. Halting for an instant, they covered their eyes to shield them from its dazzling whiteness, then suddenly turned and fled in panic. But even had they not been barbarians, even had they been trained soldiers of a highly civilised people, how bewildered they would have been to find themselves suddenly in such a brilliant light that their eyes were blinded so that they could not see to pick their way; and then, in a few seconds, just as the pupils of their eyes had contracted under the influence of the light, to find themselves suddenly in total darkness! Such alternations of dazzling light and black darkness would render the march of an attacking force over a broken country toward a fort a very difficult undertaking, for it should not be forgotten how dependent we are upon our eyes for our most simple actions, and how much our eyes assist us, even in the dark.

It may be pointed out here that the search light, like all other military instruments, must be used with judgment. It should not be used, for instance, when it is important to keep your position secret from the enemy, unless the advantages of observing him outweigh the disadvantage of disclosing your own position, or unless you can immediately extinguish your light, and change your position. In order to use the search light effectively on board ship, there should be four on each side of the ship. Search lamps are of much higher power than any other lamps that have ever been made, and the effect of the white cylinder of light, as it touches up the different points of the land or sea over which it is made to rapidly pass, is striking and beautiful in the extreme. The people of Philadelphia may remember the naval search light with which I used to illuminate the city last autumn, and do not have to be assured of its power and beauty. The best idea that I got of its illuminating effect was got one night when I went to the tower of the Pennsylvanian Railway depot, and watched the light stationed at the Electrical Exhibition building on Thirty-Second-street. The ray of light, when turned at right angles to my direction, looked like a silver arrow going through the sky, and when it was turned on me I could read the fine print of a railroad time-table at arms' length. For signalling at night, incandescent lights and search lights have both been used, the search lights being employed to reach long distances, or to reach points hidden by hills or other intervening objects. In using the search light in this case, the beam is thrown into the sky, and signals are made by showing long and short flashes, or by interrupting the beam in accordance with any preconcerted code. Flashes from the search light which I had at the Electrical Exhibition last autumn were seen from a distance of thirty miles. In using incandescent lamps for night signalling, the simplest way is to arrange a keyboard with keys marked with certain numbers, indicating the numbers of lamps arranged in a prominent position, which will burn while that key is being pressed. If it be desired to signal the number 5348, for instance, meaning, let us suppose, "Prepare to receive a torpedo attack," it is only necessary to press in succession keys marked 5, 3, 4, and 8, and the light of 5, 3, 4, and 8 lamps will successively blaze out and expire. Other codes, of course, can be used; the Morse code, for instance, in which a dash can be denoted by two lamps and a dot by one. One lamp could, of course, be used, the dot being denoted by a short flash and a dash by a long flash; but it is found best, practically, not to use time intervals in optical telegraphy.

Electric lights have been used considerably of late in photographing the bores of great guns. Views can be thus obtained of any part of the bore, showing whether the gun has been accurately bored and rifled, and showing how the metal is standing the erosion of the powder gases. One of the needs arising in modern warfare is means for handling heavy ordnance with speed and precision, and for bringing up ammunition. Guns, carriages, and ammunition have increased so much in weight, that it has become more difficult to handle them quickly than it used to be, and yet the speed of ships has so increased that there is more necessity for handling them quickly. The electric motor will certainly be used for handling ordnance on board ships not very heavily plated with armour, for it is clear that a small wire is a much more convenient way of conveying energy to a motor of any kind, and is much less liable to injury in action than a comparatively large pipe for conveying steam, compressed air, or water under pressure; and, besides, the electric motor is the ideal engine for work on board ship, by reason of its smooth and silent motion, its freedom from dirt and grease, the readiness with which it can be started, stopped and reversed, and its high efficiency. In forts, Colonel Hamilton, U.S.A., says that heavy guns must be worked by dynamo-electric machinery, since some other power than manual power must be employed, and since electricity is better than steam, compressed air, or water under pressure, because it can be conveyed from a central source by a single wire. Now, in forts, it is clear that the dynamos for search lights and incandescent lights, and for generating power for the electric motors for handling the guns, could be placed in a well-protected spot, and the wires leading therefrom could pass to the guns through underground pipes, where they would be well protected from projectiles, and the guns could be pointed in any desired direction with speed, silence and precision, by the simple turning of a lever or the moving of a switch.

It is probable that, in the near future, every man-of-war and every fort will be fitted with a complete "electrical system," well protected from projectiles, which will include dynamos capable of supplying a very large amount of electrical energy to a system of mains, from which all the incandescent lights, all the search lights, and all the motors of different sorts can draw the supply of energy requisite for their needs.

Electrical launches have been tried abroad to some extent, and with results which — though not completely satisfactory—give promise of success in the future. These boats are propelled in the same way as other boats—that is, by a propeller revolved by an engine—except that the engine is an electrical, instead of a steam engine. The electrical engine draws its power from what are called storage batteries carried in the boat. These storage batteries are first charged by a dynamo ashore or on board ship, and then are capable of rendering up to the motor the electrical energy stored in them, so that the motor is made to revolve, and thus cause the revolution of the propeller and the advance of the boat through the water. These electrical launches have carried hundreds of people, and have made a speed of about eight knots per hour, and the electric engine has worked perfectly well; but there has been considerable trouble with the storage batteries. Now, these storage batteries are improving every day, and as their defects do not seem irremediable, and as a great number of electricians are devoting study and experiment to them, we may hope that storage batteries will soon be efficient and durable. This done, the electric launch will certainly replace the steam launch in warfare, by reason of the quickness with which an electrical launch can be got ready, as there are no fires to be lighted, and, above all, by reason of the noiselessness of the electro-motor, and of the fact that in an electrical launch no flame ever flares up above the smoke pipe. With steam torpedo boats this flame frequently betrays them—that is, if the noise of the exhaust has not already done so. In using

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electrical launches in warfare, two sets of storage batteries will, of course, be necessary, so that one set can be replaced by another, and used while the first set is being recharged.

A novel application of electricity has recently been made in what have been named "electric sights." It is well known that it is difficult to get a sight at an object in the dark—first, because the object itself cannot be distinctly seen, and, second, because the front sight of the gun cannot be distinctly seen. Now, Mr. Gaston Trouvé has recently invented an electric sight no larger than the ordinary front sight of a musket, which consists simply of a filament of fine wire in a glass tube, covered with metal on all sides save at the back. It looks much like an ordinary sight, except to a man looking along the barrel towards the back of the lamp, but a man so looking sees a fine, incandescent wire. The battery is said to be no larger than a man's finger, and to be attached to the barrel near the muzzle by simple rubber bands, so arranged that the act of attaching the battery to the barrel automatically makes connection with the sight, and so arranged, also, that the liquid of the battery is out of action except when the musket is brought into a horizontal position for firing. To throw a good light upon the target, the same inventor has devised a small electric lamp and projector, which is placed on the barrel near the muzzle by rubber bands, the battery being held at the belt of the marksman, with such connections that the act of pressing the butt of the musket against the shoulder completes the electric circuit, and causes a bright cylinder of light to fall on the target, thus bringing it out into strong relief, and enabling the marksman to get as good a shot as in the daytime. An application of electricity coming somewhat into use abroad in Continental armies is in connection with ballooning, which has received there the benefit of considerable attention and experiment. It is well known to all here that balloons have been much used for observing the movements of the enemy from a distance, and now it is reported that not only have balloons been successfully fitted with telephones, for communicating at once to people on the ground the nature of the information gathered, but also with small search lights, by which the ground can be illumined for a considerable distance at night, and the enemy's manœuvres discovered. Incandescent lamps have also been sent up in small translucent captive balloons, and under small ordinary captive balloons, and signals have been transmitted to a distance by making and breaking the current according to a preconcerted code.

Yet another way in which electricity will undoubtedly be used in any future war between civilised powers is in submarine boats, or boats which go beneath the surface of the water, to attack ships below the water line. Though it cannot be said that submarine boats have ever yet been successful, still, submarine boats are being improved, and men have always been found willing to risk their lives in them. Some have been devised of late years in which the propelling power is electricity derived from storage batteries.

In submarine diving the telephone has been used with success in maintaining constant communication between the diver and his attendants above water; and the incandescent lamp, suitably protected, has also been lowered into the water to light him at his work. Submarine diving will certainly play a part in future wars, the diver descending to cut an enemy's torpedo cables, or to inspect or repair damages to submarine mines or to ships. Progress is now beginning on what have been christened "electrical guns," in which the cartridge contains an electric fuze, which is ignited by pressing an electric push-button on the gun, instead of containing the ordinary percussion primer, which is struck by a hammer or bolt when the trigger is pulled. At present this invention has not reached the practical stage, and the necessity for a battery to fire the cartridge is decidedly an objection. Yet we should remember that the battery required is very small, that it needs very little care, and that it will last a long time. We should also note that an electric gun possessses the great advantage that a better aim can be got with it than with one fired by a trigger-hammer, for the reason that the hard pull of a trigger causes a movement of the barrel, except in the hands of the most highly-skilled marksman. Now, this hard pull of the trigger is a necessity, since the hammer or bolt must have considerable mass in order that it may be strong enough to strike the primer with sufficient force to explode it, and having considerable mass, it must have, necessarily, considerable inertia, so that it needs a deep notch in order to hold it firm at full cock when jarred, and this deep notch necessitates a strong pull on the trigger. But with an electric gun the circuit-closing parts can be very small and light, and can be put into a recess in the butt of the gun out of the way of chance blows, so that when it is desired to fire, a very light pressure of the finger is all that is needed, and yet from the small inertia of the parts a sudden shock will not cause accidental closing of the circuit and firing of the gun.

We have now taken a running survey of the uses of electricity in war, and we find that they include nearly all the uses to which electricity can be put. Warfare now means more than the mere handling and provisioning of troops and ships; it means, in addition, the intelligent employment of scientific instruments. Particularly is this the case with naval warfare, for a modern ship, considered as a whole, is, in itself, the most elaborate, complicated, and powerful machine existing. Science has made warfare a greater thing than scientists themselves foresaw, for it has put into the hands of our naval and military commanders weapons surpassing in power and length of reach the fabled weapons of mythology. Yet our wonder and admiration at what has been accomplished pale before our wonder and admiration at what will surely be accomplished. Progress is marching with rapid steps. Looking forward to the future with the light the past affords us, we see the promise of great things to come. Let us welcome each new triumph of the discoverer and inventor, and take advantage of every resource that science can suggest. War is a sad necessity, but it comes seldom to a nation known to be prepared. Let us thoroughly prepare ourselves. Then, if war does unfortunately come, we need not fear the issue.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Dec. 30.	Business Done Week Ending Dec. 30. Highest.	Lowest.
Anglo-American	30½, 31½	31½	—
Do. Preferred	52½, 53½	54½	52½
Do. Deferred	9, 10	11	9¾
Brazilian Submarine	10⅝, 10⅞	10⅞	— x.d.
Cuba	10¼, 10¾	—	—
Do. Preference	17½, 18½	—	—
Direct Spanish	1½, 2	—	—
Do. Preference	11½ 12	12	—
Direct United States Cable	9⅛, 9⅜	—	—
Eastern Telegraph	11⅝, 11⅞	11⅞	11¾
Do. 6 per Cent. Preference	13½, 14	—	—
Do. 5 per Cent. Debentures, 1899	105, 108	—	—
Eastern Extension	12⅜, 12⅞	13	12¾
German Union	9½, 10	—	—
Globe Telegraph and Trust	6⅞, 7⅛	7⅛	7
Do. Preference	13⅜, 13⅝	13½	—
Great Northern	14½, 15	—	—
Indo-European	32, 33	—	—
Reuter's	7, 7½	—	—
Submarine	200, 210	205	—
West India and Panama	⅝, ⅞	—	—
Do. 1st Preference	8, 8½	8¼	—
Western Brazilian	6¼, 6¾	6½	—
Western Union 7 per Cent. 1st Mortgage	117, 121	—	—
Do. 6 per Cent. Sterling Bonds	100, 104	—	—

TELEPHONES.

Consolid. Telepho e and Maintenance	⅞, 1	15-16	—
Oriental	3-16, 5-16	—	—
United Telephone	12½, 13	12¾	12⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	4¼, 4½	4⅝	3⅝
Do (fully paid)	6, 6½	6 7-16	5½
Hammond Light (£3 15s. paid)	1-16, 3-16	—	—
Swan	2⅛, 2⅜	2⅜	1⅝
Maxim-Weston	⅜, ½	—	—

MISCELLANEOUS.

Telegraph Construction	36, 37	37	36½
India Rubber, Gutta Percha, and Telegraph Works	24, 25	24¾	—

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NOTES.

South of England Telephone Company.—The address of this company will in future be 50, Old Broad-street, London, E.C.

West Coast of America Telegraph Company.—This company have removed to their new offices, 50, Old Broad-street, London, E.C.

The Brazilian Submarine Telegraph Company.—The traffic returns of this company for the week ended 1st January amounted to £2,569.

Electric Telegraphs. — Taquin and Ettieyhausen, in Vienna, in 1836, erected an electric telegraph, the wires being partly overhead and partly underground.

Diary for the Watch.—Messrs. Kendal and Dent have prepared a little almanac to go inside the watch case. The specimens sent are, though small, quite clear.

Eastern Telegraph Company.—The traffic receipts of this company for the month of December amounted to £53,179, against £53,036 in the corresponding period of 1884.

Direct Spanish Telegraph Company.—The estimated traffic receipts of this company for the month of December, 1885, were £1,754, against £1,748 in the corresponding period of last year.

Eastern Extension Telegraph Company.—The traffic receipts of this company for the month of December, 1885, amounted to £34,785, and to £41,426 in the corresponding period of 1884.

The Telephone and Railway Signalling.—The telephone is being rapidly introduced on the German railway lines at places where the old electro magnetic signalling appliances can be superseded with advantage.

Personal.—The Royal Humane Society have lately awarded their bronze medal and certificate to Mr. Herbert Tomlinson, Demonstrator of Natural Philosophy at King's College, London, for saving a young girl from drowning at Seaford, Sussex.

Woodside Electric Works.—We have received the catalogue of the firm of J. D. F. Andrews and Co., Glasgow, giving full particulars as to the appliances and plant manufactured and sold by them in connection with Electric Lighting industry.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 1st January, 1886, were £2,150, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Great Northern Telegraph Company.—The traffic receipts of this company for December amounted to £20,280. From 1st January to 31st December, £284,720; against, in the corresponding months of 1884 and 1883, £276,280, and £254,480 respectively.

Mechanical Telephone at Dundee.—At a meeting of the Dundee Harbour Trusts on Monday, a Sub-Committee of the Works Committee was instructed to report as to the desirability of adopting the mechanical telephone for short distances at the Harbour.

The Patent Laws.—The first meeting of the Departmental Committee appointed by the President of the Board of Trade to inquire into the working of the Patent Laws will be held early next week. The inquiry is expected to be a protracted one, on account of the mass of detail involved.

The West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half month ended the 31st December are £2,017, as compared with £2,359 in the corresponding period of 1884. The September receipts, estimated at £3,876, realized £3,913.

Lancashire and Cheshire Telephone.—We have received from the Lancashire and Cheshire Telephonic Exchange Company a card almanac for office use, illustrated by pictures of the various instruments and apparatus used in telephony, the whole forming a neat and handy card for reference.

International Society of Electricians.—We notice from the *Proceedings* just received that it is intended to organise a series of public lectures to be given in the spring, which it is hoped will attract the same attention as those given at the Exhibition last year, which were held at the Observatory.

Chess by Telegraph.—An intercolonial chess match has been played by telegraph between New South Wales and Victoria, resulting in a win for the latter. Victoria won three games and lost one, while New South Wales won one and lost three. The other two games were unfinished, both being in favour of Victoria.

Sir Henry Bessemer.—It is not generally known that this gentleman, whose greatest successes have been won in other directions, was an earnest worker and one of the pioneers in electro-deposition. About 1834 he electro-deposited copper on lead castings so as to produce antique heads in relief for mantelpiece ornaments.

Silicium Bronze.—We shall be glad if our readers will send us information relating their experience in the use of this wire for electrical purposes. We have, during the past year, received information that it is not trustworthy material, but as no doubt many people have used it, greater experience will enable us to somewhat decide the question.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of this company during the month of December was 3,023, estimated to produce £2,450, against 3,001 messages, producing £2,553 in the corresponding month of last year. The traffic receipts for the month of September, estimated at £2,100, realised £2,160.

Electricity at the Antwerp Exhibition.—We have received from M. Charles Mourlon, a report of about 300 pages dealing with the electrical exhibits at the recent Exhibition at Antwerp. The majority of the exhibits present little or nothing new, but, nevertheless, they have been described in a very interesting manner by the author of this report.

Thermo-Electricity.—Little attention is paid to this branch of electrical investigation, but although, as Lord Rayleigh has shown, we cannot expect great things from it, there surely remains much that can be done. Have we really advanced much beyond the rudiments? Thermo-electric batteries start from about the year 1832, when Dr. Botto, of Turin, made one out of platinum and iron.

Globe Telegraph and Trust Company.—The directors of this company have declared an interim dividend on and after the 18th inst. of three shillings per share on the preference shares, less income tax, and of one shilling and sixpence per share on the ordinary shares (income tax having already been deducted) for the quarter ending the 18th January, 1886. The transfer books are to be closed from the 11th to the 18th January, both days inclusive.

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Electric Light Installation.—Messrs. Colville and Sons have resolved to introduce the electric light into their extensive iron and steel works at Motherwell, and Messrs. Norman and Sons, Glasgow, have been instructed to fit 200 incandescent lights and 32 arc lamps. These are guaranteed to burn for a period of eighteen hours at a stretch. The new screw steam yacht "Mohican," belonging to Mr. John Clark, Paisley, has also been fitted up with the electric light.

Earthquake in South Devonshire.—The neighbourhood of Dartmouth and Kingsbridge was visited by a slight shock of earthquake on Monday forenoon at twenty minutes past ten. At Stoke Fleming a number of persons felt the vibration, and at Stokeferry some little damage was done by it. The phenomenon was most severely experienced at Torcross, where much alarm was created, especially in houses near the beach. At Stoneham, Chillington, and Frogmore, slight oscillations were also experienced.

Lighting a Christmas Tree.—At a children's evening party given by Mr. Albert Kisch, of 3, Sutherland-avenue, W., nearly a hundred children being present, a large Christmas tree was successfully lighted by means of the electric light by Messrs. Woodhouse and Rawson, thus giving the whole a most striking effect without the slightest danger of fire or destruction to the handsome presents borne by its branches. The current was supplied from accumulators placed in the corner of the room.

The Electric Lighting Act.—According to the *Standard* the only Bill before the new Parliament relating to the electric light is promoted by the West London Electric Lighting Company, which asks for an extension of time within which to carry out the powers conferred upon them by several provisional orders, which have from time to time been granted to the Company under the Electric Lighting Act of 1882. They also seek to exempt themselves from certain provisions in that Act, which define the terms upon which electricity shall be supplied.

Magnetised Cables.—Advices from America state that tests made of the elevated railway structure and the Brooklyn bridge cables, East River Bridge, show that they are magnetised. The induced magnetism from the earth is supposed to have been fixed by the jarring to which these structures have been subjected while under magnetic influences. The bottom parts of all the pieces of iron thus magnetised show north polarity, and the cables of the bridge are said to be magnetised in the direction of their diameter; the upper surface of the cables throughout their length, being of south polarity, and the lower surface of north polarity.

Advertisers and Battery Supplies.—The replies to Mr. F. Issels' inquiry are almost all from firms and companies in advertisement of their own wares. We rather expected this would be the case. Letters containing similar inquiries reach us constantly and are generally answered privately. In America the firms who supply such wares advertise them in the ordinary way. In England the great desire seems to be to get the wares advertised for nothing. Some of the letters received have been sent to our correspondent by post, as we must emphatically decline to make our correspondence pages the place for advertisements.

Telegraphic Communication with the Continent.—At a meeting of the Liverpool Chamber of Commerce, the subject of improved telegraphic communication with the Continent was brought up, and a memorial to the Postmaster-General was adopted, pointing out that owing to the many sectional divisions of wires and cables, and the complicated arrangements existing in the Exchange Telegraph Office, serious delays take place in messages sent from Liverpool to Hamburg, Berlin, Havre, Paris, Frankfort, Vienna, Milan, Moscow, and St. Petersburg, and suggesting that nothing short of an adequate provision of direct wires from Liverpool to the principal Continental cities would remedy the evils complained of.

The Tape System.—The petition presented to the Stock Exchange Committee, says *The Times*, the object of which is to restrict the delivery of prices by the Exchange Telegraph Co. to members and such other persons, if any, as may be privileged by the Stock Exchange, was considered on the 6th inst. We understand that evidence was produced which was strongly in favour of the Exchange Telegraph Company being given an official *status* in the House, under certain conditions, but that the committee decided to adjourn the matter to a future day. Negotiations with the Exchange Telegraph Company are, we believe, going on informally on behalf of the Stock Exchange Committee, and the result will probably be known shortly.

Underground Wires.—The Standard Underground Cable Company, of Pittsburg, U.S., have lately laid an experimental electrical cable, connecting the headquarters of the police and fire departments. A trench about 4ft. deep was dug along the gutter, in which a wooden box to contain the cables will be laid. The cables consist of six insulated copper wires pressed in a malleable lead pipe and laid side by side in the boxes. The latter when closed up are to be covered with roofing pitch. All the wires of the fire alarm telegraph running out of the headquarters in Mercer-street are to be removed from the tall masts in front of the building and connected with the underground cables, and the police telegraph wires are to be similarly treated.

The Telegraph and Lighthouses.—At a meeting of the Works Committee of the Dundee Harbour Trustees, the engineer called attention to the unsatisfactory nature of the telegraphic communication between the Dock Office at Dundee and Buddonness High Lighthouse, and the committee recommended that the telegraph wire between Earl Grey Dock Office and the High Light at Buddonness be disconnected from the instrument at the Coastguard Station at Broughty Ferry, and so form one uninterrupted line between the Dock Gate House and the Lighthouse, and that a connection be effected between the Dock Gate House and the Coastguard Station by means of the National Telephone Company's system. At a meeting of the Harbour Trust on Monday, the recommendation of the committee was approved.

Early Patents.—The earliest patent mentioned in the "Abridgments of Specifications" relating to electric or magnetic subjects is that of Gowin (or Gowan) Knight, dated June 10th, 1876, and relates to the construction of compasses so as to prevent them being affected by the motion of the ship; in fact, most of the earlier patents relate to compasses. It is interesting to notice, however, that in these early days of patents the applications of electricity physiologically were studied, for Edward Nairne in 1782 patented an invention to affect the body in any part with either kind of electricity, and Benjamin Douglas Perkins in 1798 professed to cure aches, pains, and diseases in the human body by drawing certain metals over the parts affected. Henry Pinkus in 1834 embodies in his patent the use of magnetic attraction to propel carriages.

The Snow Storm and Overhead Wires.—The daily papers will have called sufficient attention to the damage to overhead wires caused by the snow storm of Wednesday last in the London district. As might be expected, both telephonic

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and telegraphic communications were considerably interrupted. Communication of this kind has become an essential part of civilised life, and we are so accustomed to rely upon a certainty of telegraphic communication that when a breakdown occurs we feel it the more keenly. With regard to telephony we have always contended that the system pursued, instead of developing one of the greatest of modern discoveries, is really keeping it back. We should like to see the telephone in every house. We think if a right system were adopted, that a few years would see its use so extensive that a house without it would be the exception and not the rule. It is not only the cost which arises from the damage done by snow storms, but the discredit which attaches when the instrument fails at a time it is most needed.

SINGAPORE.—The introduction of the electric light into this colony may now be accepted as an accomplished fact, says the *Straits Times*. Mr. E. J. Wells has been exhibiting the latest form of the incandescent lamp at his works in River Valley Road for some weeks, and he is waiting the arrival of suitable machinery in order to exhibit the more powerful arc lamp. Mr. Wells is also in course of forming a company, to be called the Singapore and Straits Electric Light Company (Limited), for the purpose of furnishing the necessary capital to carry out the lighting of private dwelling houses and public buildings in the colony and the native states on an extensive scale, and he has already obtained from the Municipal Commissioners a concession of the right to lay wire in one district of the town, and a promise of a further concession so soon as the company is registered. It may here be noted as a curious circumstance that it is to the same gentleman who is now introducing the electric light into the Colony that Singapore was indebted for the introduction of gas about 24 years ago.

SOCIETY OF ARTS.—The following papers are announced for reading before the Society of Arts at meetings previous to Easter:—At the ordinary meetings on Wednesday evenings, at 8 o'clock:—"Results of Experiments on Mechanical Motors for Tramways made by the Commission at the Antwerp Exhibition," by Capt. Douglas Galton, D.C.L., C.B., F.R.S. (Sir Frederick Abel, D.C.L., C.B., F.R.S., chairman of the society's council, will preside); "Machinery in Mines," by Henry Davey (Sir Frederick Bramwell, F.R.S., Pres.Inst.C.E., will preside); "Artistic Bronze Casting," by George Simonds; "Calculating Machines," by C. V. Boys; "Domestic Electric Lighting," by W. H. Preece, F.R.S.; "The Experiments with Lighthouse Illuminants at the South Foreland," by E. Price Edwards. In the Applied Chemistry and Physics Section, on Thursday evenings, at 8 o'clock—"Magnetism of Ships and the Mariner's Compass," by Wm. Bottomley, jun.; "Photography and the Spectroscope in their Application to Chemical Analysis," by Prof. W. N. Hartley, F.R.S. The next course of Cantor Lectures will be by Prof. H. S. Hele Shaw, on "Friction."

"CHEMICAL ELECTRIC LIGHT."—A company appears to have been formed at Boston, Mass., for the purpose of manufacturing and supplying this singular commodity. The prospectus informs us, however, that the light is so called because it is obtained from a primary battery fed by Volta Pavia, a "new chemical." The name is certainly new; but of the chemical we can only make out for sure that it is sold at five dollars per gallon when there are any buyers. It is said that batteries containing this solution possess five times the efficiency of other primary batteries—which is not so sure; and that incandescent lamps can be maintained by it at "full candle-power" for 200 hours on one solution without renewal—which is rather vague; and lastly, that Volta Pavia in a medical battery has done "consecutive work for three months, which formerly required replenishing every week"—which is rather ungrammatical. The trade mark of this enterprising firm is a pair of frog's legs in convulsions, delicately intended as an allusion to Volta, but in their present relation more likely to remind us of that ingenious speculator the owner of the Jumping Frog.

THE ANGLO-AMERICAN TELEGRAPH COMPANY AND ITS SHAREHOLDERS.—We are strongly of the opinion that the action of the shareholders, or rather of a section of the shareholders, as reported in another column, is ill-considered and ill-advised. It is impossible for us to enter into any lengthy discussion as to the policy of the directors—they must combat the criticism themselves; but when all the conditions of Atlantic telegraphy are considered it is difficult to suggest a better policy. On one point we shall speak, and that is as to the reserve fund. The existing fund is not large enough, and the directors are perfectly justified in increasing it, even to double its present amount. The shareholders should consider that their property has been attacked again and again of late years; that opposition has sprung up; that the carrying capacities of the Atlantic cables are far in excess of the requirements; and instead of staying the hands of their directors the shareholders should give them full powers. Just when the directors are in the greatest straits as to the best course to be pursued, the shareholders, knowing but little of the real position, precipitately interfere—a policy which, if persisted in, will end in disaster.

ELECTRIC ACCUMULATORS.—In 1883 the Academy of Mining and Forestry in Schemnitz, Hungary, was furnished with incandescent lamps, the electric current being supplied by about 90 accumulators. A paper by S. Schenek and S. Farbaky describes the construction of the accumulators employed, and gives an account of some observations made by the authors. To study the behaviour of the sulphuric acid during the condensation of the discharge of the current a series of experiments was made. It was found that when the accumulators are charged the sulphates are decomposed, sulphuric acid being liberated; whilst on discharging, the sulphates are again formed, the free acid being recombined. To determine the ratio of accumulated energy to acid set free, and the ratio of discharged energy to acid fixed, a further series of trials had to be made. The results appear to show that when the accumulators are charged 2·23 grams of sulphuric acid are liberated per ampere per hour, and that during their discharge 2·25 grams of acid are fixed, giving a mean value of 2·24. The authors term this number the electro-chemical equivalent of sulphuric acid for an electric force of one ampere per hour. From this value some useful data in regard to the preparation, treatment, and application of electric accumulators are said to be derived.

THE TELEPHONE QUESTION.—Writing to the *Scientific American* on this question, Mr. Berliner says:—"Reis telephones, when used *as described by him*, will not transmit speech. He who invents a new *art* is entitled to the fame and financial success based upon a patent for such an art. If the assertions that Reis *did* occasionally understand spoken words be true, that did not constitute the art of speaking, because an art is something that can be *controlled*, and Reis then only spoke because the action of his transmitter occasionally was *beyond* his control. Five years before Reis made his instruments, their principle was *fully published in a prominent scientific paper in the city where he then lived, under the name 'telephony,' and he was then an active*

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member of the physical society of that place. Those principles were first accurately expounded by Charles Bourseul, of whom said publication spoke. The method of producing undulations by immersing an electrode in liquid, which is the subject of Mr. Gray's caveat, was described in Mr. Bell's original application, which was sworn to several weeks before Mr. Gray's caveat was *written.* Hence it is absurd to assert that Mr. Bell obtained that idea from Mr. Gray's caveat. That we can *now* speak with the Reis instruments is no more proof in favour of Reis than the fact that we can also *now* speak with a Morse key and sounder is a proof that Morse invented the art of speaking by electricity. Both, together with other electrical instruments, can to-day be manipulated on Bell's principles so as to transmit and receive speech."

Royal Institution of Great Britain.—The winter programme in connection with the Royal Institution opens with a series of Christmas lectures by Prof. Dewar on the story of a meteorite, and the list of lectures down till Easter next includes such names as those of Dr. Ball, Astronomer Royal of Ireland, whose subject is the astronomical theory of the great ice age; Mr. R. S. Poole, Mr. C. T. Newton, Prof. A. Gamgee, Mr. W. C. Roberts-Austen, Prof. W. Boyd Dawkins, Prof. Tyndall (who gives four lectures on light), Mr. Archibald Geikie, and Dr. Taylor, of St. John's College, Cambridge. The Friday evening meetings begin on Jan. 22, when Prof. Tyndall discourses on "Thomas Young and the Wave Theory," and the programme of probable arrangements is one of sustained interest. The Royal Institution, as is well known, is an association of individuals who are devoted to science and desirous to promote its advancement. It includes two laboratories for the promotion of chemical and physical science. In the physical laboratory the researches of Prof. Davy, of Prof. Faraday, and of Prof. Tyndall were conducted; while in the chemical laboratory Prof. Falkland made some of his most important researches in organic chemistry; and more recently Prof. Dewar has conducted his spectroscopic researches and his experiments relating to the chemistry of the electric arc and the condensability of gases. Both forms of the electric light, the voltaic arc and the magneto-electric spark, were, indeed, first introduced at the Royal Institution by Davy and Faraday. In addition to the public lectures and the weekly meetings of the members, there are a model room, containing scientific apparatus of historical interest and of present use; a library of about 50,000 volumes, a reading room for study, and a newspaper room. It only remains to be added that the institution is self-supporting, and has never received any aid from Government.

As Others See Us.—Our contemporary, *The Journal of Gas Lighting*, in its summary of the year's work, says:—"With regard to the electric light, upon which we have considered it our duty to keep watch from week to week, there is little to be said that will give satisfaction to its supporters. The history of 1885 is the same as that of 1884, 'only much more so.' Very few companies connected with electric lighting as a business remain solvent; and these keep afloat by the comparatively small amount of trade which they can secure in the way of making and dealing in electrical machinery. Electric lighting, as a business independent of the trade in apparatus, does not at this time exist in Great Britain. Not one of all the Provisional Orders and licenses granted by the Board of Trade under the Electric Lighting Act has been carried out by the undertakers; and there is not the slightest likelihood of any improvement in this respect. The blame for this utter collapse of electric lighting as a business has been ascribed to the socialistic purchase clauses of the Electric Lighting Act; and there is a rumour afloat that these are to be amended in the next session of Parliament. It is impossible for those who are interested in industries protected by statute to regret that discredit has thus been thrown upon Mr. Chamberlain's confiscatory legislation, because it will tend to discourage fresh movements in the same line, having for their object the retrenchment of statutory privileges already granted. It may well occur to those most given to cry out in condemnation of what they are pleased to call 'monopolies' that, after all, the supply of a thing under a regulated monopoly may be preferable to no supply at all. The lesson should not be allowed to pass unheeded. At the same time, the electricians who swarmed into the Board of Trade with applications for Provisional Orders immediately after the passing of the Act, knowing perfectly well what were its provisions, are not justified in declaring that it has destroyed their occupation. What the Act undoubtedly did destroy was a host of speculative companies which, with limited and encumbered capitals, presumed to apply for right to take possession of all the towns of the United Kingdom. It has been rightly said that the Electric Lighting Act does not apply to the entire universe; and when electricians can show that they enjoy in Bombay or Melbourne, in Florence or Amiens, a success which is denied them here, the offending law will soon be repealed. How long would a law remain on the Statute Book if the capitalists of England were assured that it, and it alone, stood in the way of a profitable employment of the idle gold which fills their coffers to overflowing? There has certainly been some progress in electric lighting; but it has been in the improvement of details of apparatus and arrangement in the hands of private firms, who do the greater part of such legitimate work of this kind as is required. Desperate attempts have been made to claim success for the transmission of force by electrical currents, according to a system imagined by M. Marcel Deprez. The genuineness of the results obtained by Deprez has been questioned; and the latest news concerning the experiments is that there has been a serious breakdown, accompanied by much damage to machinery. There is no longer any talk of primary batteries for domestic lighting which will pay for the light by the value of the residuals of the cells; and a practical meter is still to seek." The whole of the above is so evidently biassed that we who know how utterly fallacious are the various statements can afford to say "let those laugh who win." From first to last this trade contemporary has perverted the truth, and those who trust it will lamentably suffer in the long run.

Development of Electricity.—M. E. Dorn, in *Wiedemann's Annalen*, has given the following experimental proof of the law that both electricities are developed at the same time and in the same quantities, for pyroelectricity. According to the *Phil. Mag.* he says:—"That both electricities are produced in equal quantities in all cases of electrical excitation is a principle generally admitted, though the experimental proofs are not numerous. It appeared to me desirable, therefore, to prove the above principle for pyroelectricity, particularly as here an apparently paradoxical case occurs. If a crystal of tourmaline is warmed at one end and then rapidly passed through the flame, it is first found to be almost entirely unelectrical. As it cools somewhat, considerable disengagements of electricity occur which are occasionally *of the same kind at both ends.* The above principle requires that the same kind of electricity occur in equal quantity on the lateral faces, or in the interior of the crystal. A test is furnished by the principle, that a quantity of + electricity in the interior of a shell-shaped conductor would induce − electricity on its inner, and + electricity on its outer side, whatever was the distribution

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of the original + electricity. If the tourmaline, after being heated, is brought inside a conducting but insulated hollow body, an electrometer connected with the latter should show no signs of electricity as the crystal cools. The arrangement of the experiment was as follows:—A brass cylinder, 4 centimetres in height and 2 centimetres in diameter, was supported on a rod of shellac, and had a lid which could be lifted off by means of an insulating rod of shellac. A third rod of shellac was fixed to the under surface of the lid, and in it was fused a thin brass wire which was wrapped round the tourmaline. The tourmaline used was of a green colour, very transparent, fractured on both sides, and for a length of 2·05 centimetre weighed 1·59 gramme. One pair of quadrants of the electrometer was put to earth. A volt was represented by a deflection of about 2·5 centimetre on the scale, at a distance of 130 centimetres, which was sufficient for the present purpose. It was more important that the insulation of the one pair of quadrants should be good, and that it should not receive a charge from the movable part of the electrometer, or from the air in the room, than that the electrometer should be very sensitive. These conditions were more than sufficiently satisfied. For when electricity was imparted to the insulated pair of quadrants, the deflection only sank in forty minutes from 14·0 to 13·3; and further, after insulation for three quarters of an hour without charge, there was a deflection of 0·4 centimetre. The shellac rod which supported the cylinder also insulated well; for after being connected with the insulated pair of quadrants, the deflection sank in eleven minutes from 38·2 to 30·4. The capacity of the insulated pair of quadrants was found in several experiments to be about seven times as great as that of the cylinder. In the experiments the second pair of quadrants, from which a wire passed to the cylinder, was connected with that to earth. The lid with the crystal was raised, the latter heated in one end of the flame of a Bunsen burner or spirit lamp, again brought into its place, and the connection with the two pairs of quadrants rapidly broken. However the heating was arranged, no deflection was ever obtained which exceeded the uncertainty of the instrument, although the quantities of electricity developed were often considerable, and were frequently of the same kind at both ends. From a long series of experiments I select the following:—When the crystal was heated at one end, and after a minute removed from the cylinder, the proof plane applied to the crystal and then to the insulated pair of quadrants showed negative electricity at both ends, the deflections at the top and bottom being 3·0 and 7·50 centim. respectively. In another case there was no apparent electricity at one end, while that of the lower sent the image out of the field. If the duration of heating was somewhat greater, and the crystal remained longer in the cylinder, there was on the top positive, and on the bottom negative, and of such strength that often, on raising the lid with the crystal, the luminous image disappeared from the scale, which is simply explained by the fact that part of the electricity induced on the cylinder is removed with the lid."

Information for the People.—The following has appeared in one of the Sheffield papers:—"We have lately had the opportunity of ascertaining a few practical details about the electric light as applied to works, which may be interesting at the present time of year. As most persons interested are now aware, there are two distinct systems of electric light—the arc, in which a brilliant bluish-white light is given by the glowing ends of two carbon rods, and the incandescent, in which a light is given by a long thin filament of carbonised thread, which is made white-hot throughout its whole length by the electricity. This filament is enclosed in a glass globe, from which all air is exhausted. The incandescent system is the one which seems to commend itself for use in mills, the lamps giving a steady manageable light equal to about 16 candles. In the latest form of lamp the thin filament is made from carbonised cotton thread, in the form of a curl, to give equal illumination all round, the ends finished off in a socket, by which it is easily fitted into the holder. This is the most practical form, and is the outcome of the union of the two best known systems invented by T. A. Edison, in America, and J. W. Swan, in England. The electricity for these lamps is not of very high pressure, and there is no danger from shocks on touching the wires, as there is in some other systems. No matches are required, the lamps all lighting together when the dynamo is started; but each lamp can be controlled, if necessary, by its own knob, and turned off and on like an ordinary gas-burner. Being enclosed in a glass globe there are no fumes, no dirt, and very little heat. It can thus be placed close to the worker, or amongst inflammable materials. If the glass breaks the lamp goes out. Moreover, to prevent danger from escape of electricity, each lamp is controlled by a piece of fusible wire which melts and breaks all contact if by accident too much electricity tends to pass. Practically about eight lamps can be kept alight for each indicated horse-power, allowing for all loss; thus for 100 lights a 6 horse-power nominal indicating about 12 horse-power would be required. For the uninitiated who wonder how the motion of a belt turning a pulley can be converted into electricity, we may say that the whole development of electric light is founded on a simple experiment of Faraday, who found that if a coil of wire is moved near a magnet, a current of electricity flows as long as the motion is kept up. The magnets of the dynamo are made very strong, and numerous coils of wire are mounted so as to be turned very quickly (800 per minute) between the very poles of the magnet; each wire as it passes gets its shock and pours little currents into the main cable, something like the water buckets on a chain pump. Where water-power is available there is hardly any expense for maintenance; the electric machinery, spinning merely in air between magnets, has very little wear and tear, save at the brushes when the electricity is taken off. These cost a few shillings a year. The only real expense is for replacement of lamps, and these last over 1,000 working hours, and of course require replacing only according to length of time burnt. Where steam-power is used the cost of fuel has to be added, but experience shows that even then, in a large mill, the saving is often considerable over gas. One great advantage is that, when required for sorting, a few lamps could be easily arranged to be run over the usual power; they then give a beautiful white light, nearer to daylight than any other artificial light. Large numbers of mills and public and private buildings have lately adopted the light, the feeling of hesitation as to its capability having now worn off. The display at the Inventions Exhibition itself gave a complete answer to those who imagine that no real progress has been made. The Metropolitan stations, Cannon-street, Monument, Eastcheap, and others, also Paddington and Waterloo, are lighted by this means. The Bank of England, House of Commons, Royal Courts of Justice, Inner Temple, and many theatres have adopted the light. Amongst manufacturers, Colmans, of Norwich, and J. and P. Coats, the Paisley cotton thread spinners, are using the light, the latter having 1,200 lamps, and they are adding thereto. We are told that the principal factory of these lamps is making them at the rate of half a million a year. It is evident, then, that though the Utopia of public supply has not yet arrived, great development has taken place."

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THE WINDING OF VOLTMETERS.*

BY PROFESSORS W. E. AYRTON, F.R.S., AND JOHN PERRY, F.R.S.

(*Concluded from page* 156.)

IV. Making b equal to nought as the least value of b attainable, we can now find the value of a to make the error a minimum. To do this we must put b equal to nought, take d equal to -1 in (9), differentiate with respect to a, and equate the result to 0.

Thus $$\phi(m)+\phi(n)-2\phi(p)=0 \quad . \quad . \quad . \quad (18)$$

where $\phi(a)$ has the signification given to it in (17).

Since $b=0$

and $d=-1$

it follows from (14) that
$$\left.\begin{aligned} m&=2-2a \\ n&=-a \\ p&=2-4a_1 \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (19)$$

therefore, from (17)
$$\phi(2-2a)+\phi(-a)-2\phi(2-4a)=0.$$

The equation cannot be solved generally, but by giving various values to a we can find which of these values makes the expression on the left hand side most nearly equal to nought, and to ascertain the value of the function for each of the values of a we can conveniently use the curve connecting $\phi(a)$ and a previously employed.

For $a=0{\cdot}5$ we have
$$\phi(1)+\phi(-0{\cdot}5)-2\phi(0)=1{\cdot}375+0{\cdot}865-2\times1{\cdot}04$$
$$=+0{\cdot}16,$$

for $a=0{\cdot}4$ we have
$$\phi(1{\cdot}2)+\phi(-0{\cdot}4)-2\phi(0{\cdot}4)=1{\cdot}43+0{\cdot}9-2\times1{\cdot}182$$
$$=-0{\cdot}034,$$

for $a=0{\cdot}3$ we have
$$\phi(1{\cdot}4)+\phi(-0{\cdot}3)-2\phi(0{\cdot}8)=1{\cdot}48+0{\cdot}936-2\times1{\cdot}311$$
$$=-0{\cdot}206,$$

for $a=0{\cdot}2$ we have
$$\phi(1{\cdot}6)+\phi(-0{\cdot}2)-2\phi(1{\cdot}2)=1{\cdot}53+0{\cdot}97-2\times1{\cdot}43$$
$$=-0{\cdot}36.$$

Plotting these points, we find (Fig. 2) that the curve for the

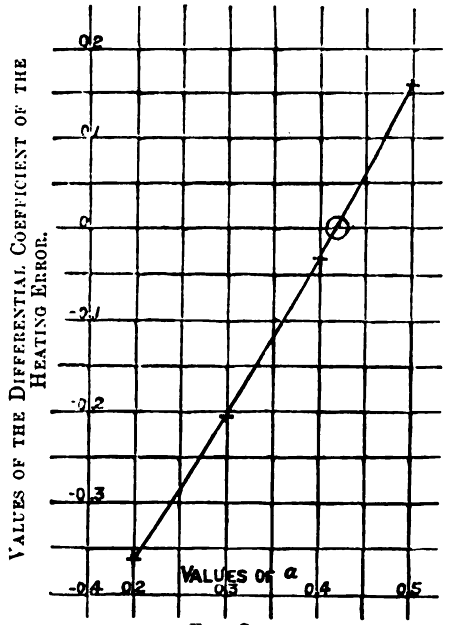

FIG. 2.

differential coefficient cuts the axis along which a is measured at a point 0, for which a has the value 0·42, or, in other words, *a equal to 0·42 makes the differential coefficient equal to nought, and hence is the value of a that makes the heating error a minimum.*

* Paper read before Physical Society.

As a check on this we have drawn the curve for the values of the heating error for different values of a (Fig. 3), and from this also it is seen that the heating error has a minimum when a equals 0·42. Hence it follows that the law of increase of the sectional area of the wire with the radius of the convolutions should in our solenoid voltmeter follow the law
$$x=x_0\,r^{0{\cdot}42}$$
in order that the error due to heating may be a minimum.

Fig. 3 not only gives the value of a that makes the heating error a minimum, but it shows by how much the heating error is increased if a has a value greater or less than 0·42. For example, if a equals 0—that is to say, if the voltmeter be all wound with wire of the same gauge—then continuing the

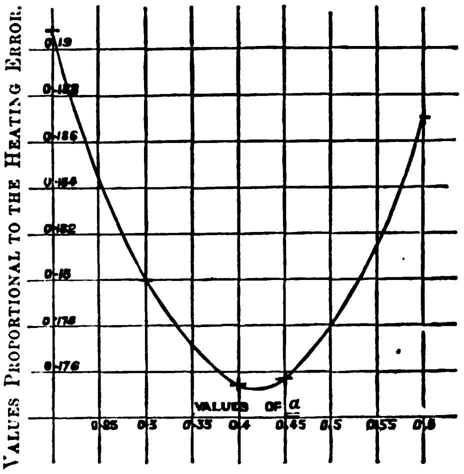

FIG. 3.

curve backwards we find that the heating error is increased by about one-third.

V. One plan of diminishing the heating error with voltmeters, and one that we have frequently employed, is to place in the same circuit with the instrument a coil wound with German silver wire, and having a resistance far greater than that of the voltmeter itself. By using wire of large diameter wound on a bobbin of large volume, and with as efficient arrangement for cooling as can be conveniently employed, the heating error can be rendered extremely small. Such a bobbin, however, is both costly and bulky, and the employment of such an outside resistance coil wastes energy, and can only be used with voltmeters in electric light and power installations where such a waste of energy is unimportant. The following investigation has, therefore, been made for the purpose of determining what must be the volume of this outside resistance coil, and what must be its resistance relatively to that of the voltmeter coil so that the heating error may not exceed any given value.

Let R be the resistance of the coil of copper wire wound on a voltmeter, let H be the rate of production of heat when the maximum deflection is obtained, then, as already shown, H will be constant for a voltmeter of a given size wound according to a definite law, whether it be wound with fine wire for a 500-volt instrument, or with thicker wire for a 50-volt one. Let C be the current passing round it when this maximum deflection is being produced, then
$$C^2\,R = H \text{ a constant.}$$

Let the increase of resistance produced by the passage of the current for some time be r, then $\frac{r}{R}$ is proportional to the product of γ, the coefficient of increase of the resistance of copper per degree of temperature into H, since, as already explained, the voltmeter is so wound that the rate of production of heat is proportional to the increase of temperature. Hence
$$\frac{r}{R} = \text{a constant, A, say.}$$

Now, let there be a resistance coil of German silver wire of uniform cross section of volume V in series with the instru-

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ment, and let us suppose that for any coils thus added the rise of temperature is proportional to the energy wasted per second per unit volume—that is to say, proportional to the rate of production of heat per unit volume.

Let R_1 be the resistance of this added coil, then $\frac{C^2 R_1}{V}$ is proportional to its rise of temperature; hence, if r_1 be the increase of resistance and γ_1 the coefficient of increase of resistance of German silver per degree—

$$\frac{r_1}{R_1} \propto \gamma_1 \frac{C^2 R_1}{V},$$

$$\text{or } r_1 = B \frac{C^2 R_1^2}{V} \text{ say, where B is a constant.}$$

Hence, if e is the error due to the proportional change of resistance—

$$e = \frac{r + r_1}{R + R_1},$$

$$= \frac{AR + B\frac{C^2 R_1^2}{V}}{R + R_1}$$

Let

$$\frac{R_1}{R} = y,$$

then

$$e = \frac{A + \frac{B}{V} y^2}{1 + y} \quad . \quad . \quad . \quad . \quad . \quad (20)$$

To determine the value of these constants, A and B, we may proceed as follows:—Wind a voltmeter according to the law which is to be adopted with any or no resistance coil outside, find the potential differences P_1 and P_2 required to produce the maximum reading of the instrument—

1st. Immediately or making connection.

2nd. After connection has been made for some time;

then

$$e = \frac{P_2 - P_1}{P_1}$$

Let e be experimentally determined in two cases, one when there is no resistance coil outside, and the other when there is such an auxiliary resistance coil obtaining values e_1 and e_2 respectively. Measure y_1, that is the ratio of R_1 to R, and also V. Then from the equations

$$e_1 = A,$$

$$e_2 = \frac{A + \frac{B}{V} y^2}{1 + y}$$

the values of the constants A and B can be determined, and when determined the error arising with the employment of an outside resistance coil of any resistance and of any volume can be calculated from (20).

It is obvious that as V becomes greater the error becomes less and less, but there is a practical inconvenience n largely adding to the weight of the instrument.

VI. *To determine the best resistance to give to the outside coil of given volume.*—When V is fixed e is a maximum or minimum when

$$\frac{de}{dy} = 0.$$

Now

$$\frac{de}{dy} = \frac{\frac{B}{V} y^2 + 2\frac{B}{V} y - A}{(1 + y)^2},$$

and

$$\frac{d^2 e}{dy^2} = \frac{2\left(\frac{B}{V} + A\right)}{(1 + y)^3},$$

y must be positive, therefore $(1 + y)^3$ is positive, also A and B are both positive, therefore $\frac{d^2 e}{dy^2}$ is positive, and therefore e is a minimum when

$$\frac{de}{dy} = 0,$$

that is when

$$\frac{B}{V} y^2 + 2\frac{B}{V} y - A = 0,$$

or

$$y = -1 \pm \sqrt{1 + \frac{AV}{B}},$$

but y cannot be negative, therefore only the positive sign can be used, or

$$y = \sqrt{1 + \frac{AV}{B}} - 1 \quad . \quad . \quad . \quad . \quad (21)$$

makes e a minimum.

Substituting this value of y in (20) we find that

$$e = 2\frac{A + \frac{B}{V} - \sqrt{1 + \frac{AV}{B}}}{\sqrt{1 + \frac{AV}{B}}} \quad . \quad . \quad (22)$$

VII. *To determine the best volume and the best resistance to give to the outside coil for a given permissible error.*—From the preceding it is easy to see that if the maximum allowable value of e is given, the minimum value of the volume that can be employed is given from (22), and for this value of the volume, the best value of y—that is, the best ratio of the resistance of the outside coil to that of the magnetising coil of the voltmeter—can be calculated from (21).

VIII. *To determine the sectional area to be given to the inner wire of a voltmeter in terms of the maximum potential difference, so as to make the heating error a minimum.* By experiment ascertain the potential difference P, that is necessary to produce the maxi-mum deflection with any voltmeter of the shape and size to be employed, and wound according to the law

$$x = x_0 r^a,$$

where a has the value that makes the heating error a minimum, and which value will depend on the shape and size of the instrument, and may be calculated for any special type of voltmeter in the same way as it has been calculated in what precedes for the long range magnifying spring instrument. Then, if it is desired to wind another instrument, of the same volume and shape, so that it will have its maximum deflection given by P_2 volts, it follows, since the heating will, as already proved, be the same in the two instruments for their maximum deflections, that their resistances must be proportional to the squares of P_1 and P_2, and hence from (5), since the same law of winding is followed, that the cross section of the innermost layer of wire in the two instruments must be inversely proportional to P_1 and P_2.

To have the same heating error in the two cases, with outside resistance coils of the same shape and size, it follows from (21) that it is necessary to use the same ratio between the resistance of the outside coil and the resistance of the magnetising coil. To have a less or greater heating error in the second than in the first case for the maximum deflection, it is only necessary to determine from (22) (the constants of which have been deduced by experiment with the first instrument) the greater or less volume V of the outside resistance coil needed with the second instrument, and calculate the ratio y of the resistance of the outside coil to that of the magnetising coil by (21).

IX. As to the second error, arising from the sensibility of the instrument being temporarily varied by external magnetic disturbance, referred to in § I, this can be overcome in three distinct ways—by

1. Shielding the instrument by putting it in an iron case with very thick walls
2. Using a very powerful controlling field.
3. Using a motion of *translation*, and *not of rotation* for the coils in the instrument that is deflected by the current.

The first method, to be successful, requires that the iron case should be heavy and cumbersome, and makes it unsuitable for portable instruments. A very powerful controlling field necessitates a very powerful deflecting force, and so either makes the instrument unsensitive or necessitates a considerable expenditure of current energy in the instrument. The third

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method, consisting in giving the deflected body a *motion of translation*, is the best, since, no matter how strong the disturbing magnetic field may be, provided it is uniform throughout the small space traversed by the deflected body in its motion, no increase nor diminution of the deflection will be caused by the outside magnetic field. For this reason we have adopted this third method in our magnifying spring instruments, and experiments show that the shielding produced in this way is even better than in our older form of instruments provided with a powerful permanent magnet.

X. As to the third error, arising from certain types of voltmeters altering in sensibility, so that their constants vary from time to time. This error arises from two causes. In some voltmeters, such as those in which a controlling permanent magnet is employed, there is an error which gradually comes on from the demagnetisation of this magnet—an error which is greatly increased by a mistaken careful regular employment of a keeper for the magnets when the instrument is not in use. This error can be avoided by dispensing with a permanent magnet and using a spring or a weight, or an electromagnet which is magnetised by the current to be measured. A second time error arises from the employment of iron in the instrument, and has the effect of making the indications of the instrument depend not merely on the current passing at the time of measurement, but also on the currents that have lately passed through the instrument. This error is especially marked in those instruments in which the controlling force, or the force tending to bring the needle back to zero, in opposition to the deflecting force, is produced by the attraction of an electromagnet containing a core of soft iron wire, and which, it is *assumed*, is magnetised to saturation by the current which it is our object to measure. With small currents, however, which produce deflections in the lower part of the scale, this iron core is not saturated, and differences in the values of the readings of as much as 30 to 40 per cent. are obtained, depending on whether it is an increasing or a decreasing current that is being measured with such an electro-magnetic instrument.

XI. The fourth error, arising from the Volt standard employed by various people differing several per cent. from one another has been hitherto a very serious matter. The standards employed have usually been—

1. The E.M.F. of a Daniell cell.
2. The E.M.F. of a Latimer Clark cell.
3. A standard depending on the electro-chemical equivalent of silver and the value of the legal ohm.
4. The indication of a voltmeter graduated by some well-known maker, but graduated in a way quite unknown, probably, to the user.

Standard 1 is vague unless the details of the method employed in setting up the Daniell cell are more carefully specified than heretofore; for example, Carpart, in some recent tests of the E.M.F. of a Daniell cell made out of a U tube, with a contraction in the lower part, found it to vary from 1·111 legal volts when the zinc sulphate solution had 25 per cent. of $Zn\,SO_4$, to 1·142 legal volts when the solution had only 3 per cent. of $Zn\,SO_4$. His method of testing is based on the electro-chemical equivalent of silver and the legal ohm, and as a proof of its accuracy he finds that the E.M.F. of a Latimer Clark cell is 1·434 volts. If, however, we compare his results for a Daniell cell with 1·072 volts, as found by Sir W. Thomson when the zinc sulphate solution had a sp. gr. of 1·2, we see how Daniell's cells differ among one another.*

The E.M.F. of a Latimer Clark cell has also some vagueness attached to it unless the temperature coefficient of variation of E.M.F. of the particular Latimer Clark cell is known and taken account of. Generally the users of these cells are contented to say that the E.M.F. of a Latimer Clark cell as determined by Lord Rayleigh is 1·435 true volts, or 1·438 legal volts, and they neglect the temperature variation altogether, which amounts to about 1 per cent. diminution per 12°C. elevation of temperature with certain Latimer Clark cells.

* Since the reading of this paper this subject has been very fully treated by Dr. Fleming in a paper "On the Use of Daniell Cell as a Standard of Electromotive Force," read before the Physical Society on June 27th, 1885.

Standard No. 3 is the one that we have used for some time, and, as we have obtained very satisfactory results with it, it may be well to describe our mode of using it a little in detail. First, by means of a large number of direct comparisons with a copper voltameter, we determine the most probable value in amperes of the indications in different parts of the scale of an ammeter *fixed permanently in position* by being screwed to the table. A current is now sent through this ammeter in series with a long thick copper wire having about six ohms resistance and wound in a large open coil. This coil has attached to its two ends the standard voltmeter, which is also fixed *permanently in position*. Simultaneous readings of the ammeter and voltmeter are now taken by two observers, when a signal is given and the bridge piece of a mercury commutator is moved so as to cut off the current and connect the copper wire together with the voltmeter, which is joined with it in parallel, to a differential galvanometer. Their *time* measurements, for about 10 minutes, are taken by a third observer of the parallel resistance of the thick copper wire and the attached voltmeter. Next a curve is drawn connecting the resistance of the cooling coil with the time, and on completing the curve backwards we ascertain with great accuracy, by interpolation, the resistance at the moment of stopping the current —that is, at the moment of making the simultaneous observations on the ammeter and voltmeter. Our copper wire is sufficiently thick that for a current of some 15 amperes passing through it, corresponding with about 80 volts maintained at its ends, the time curve of its resistance, obtained after stopping the main current, is nearly a straight line with hardly any inclination to the axis along which the time is measured; or, in other words, the change of resistance due to cooling while the measurements of resistance are being made is very small and easily allowed for, and the resistance in legal ohms, multiplied by the current passing in amperes, gives, of course, the potential difference in legal volts.

In using the copper voltameter to calibrate the ammeter it is of course necessary (in order that a firmly adherent deposit should be obtained) that the area of the immersed surfaces of the anode and cathode opposed to one another should exceed the limit given by Dr. Hammerl, viz., one square decimetre per 7 amperes, or rather more than two square inches per ampere, and in our experiments we have taken care to use a larger area in proportion to the current. Our negative plates consisted of a number of separate sheets of very thin hard copper, so that the weight of the deposit could be accurately measured; the current was supplied by accumulators, and increased or decreased by a carbon resistance, worked with a screw. By watching the ammeter and slightly turning this screw, one way or the other, the current could be kept very constant for a long time. The value of the electro-chemical equivalent employed for copper was 0·3295 milligramme per coulomb, which is deduced from the mean of the electro-chemical equivalent of silver, 1·118 milligramme per coulomb, as given by Lord Rayleigh, and 1·1183 by F. and W. Kohlrausch, and by using 63·47, 107·66, 32·07, and 16 as the atomic weights of copper, silver, sulphur, and oxygen respectively. The solution of copper sulphate employed was a saturated one, the crystals of copper sulphate used in making it being chemically pure.

To avoid errors being introduced by oxidation of the copper that had just been deposited on the copper plates, they were, on being taken out of the sulphate of copper bath, on the stoppage of the current, immediately washed quickly, first in water, secondly in alcohol, thirdly with ether poured over them, and then dried.

The current that a given set of accumulators will send through a copper voltameter depends, of course, partly on the distance between the alternate positive and negative plates, and partly on the depths to which they are immersed in the saturated solution of copper sulphate. The proper arrangements of the plates to allow any particular current to pass cannot conveniently be determined with the plates that are going to be used for the experiment, as an unknown weight of copper would be deposited on them during the process of adjustment, and great delay would be introduced if the plates had to be dried and weighed after the adjustment,

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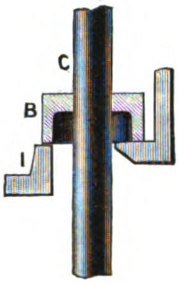
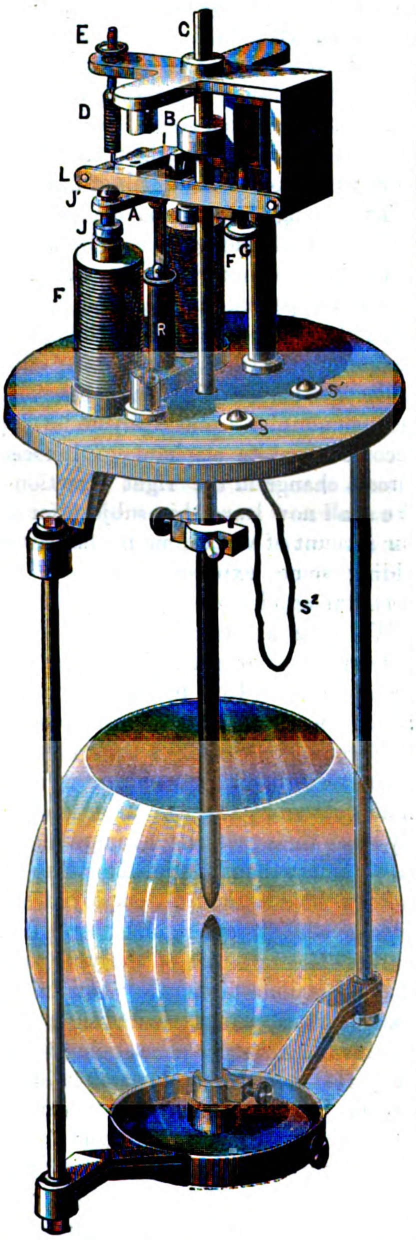
and before making the final experiment. Hence, after the proper plates to be used as the cathodes had been very carefully cleaned and weighed, a spare set of exactly the same size and shape were put into the bath, and their distance, as well as the carbon resistance adjusted, until the desired current was passing; then the spare set was removed, and the weighed set substituted for them, and the experiment carried out.

Having determined our volt-standard in the way above explained, we tested various voltmeters of different makers, and we fonnd that whereas the indication of some of them agreed very well with our standard, the indications of others differed by several per cent.

THE LEVER ARC LAMP.

We herewith illustrate the latest form of this lamp. A shows the armature, L a lever, and D a spring; E the nut for adjusting the tension of the spring D, and I a projection attached to

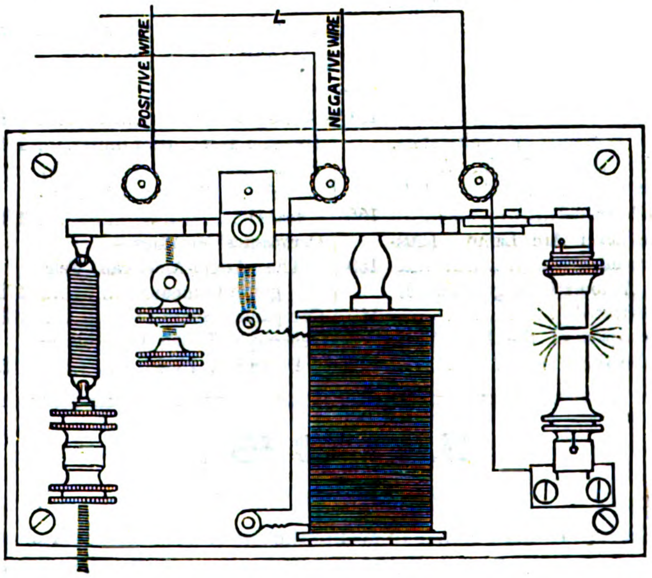




the lever L, which cants or tilts the clip B, by means of spring D; G is a set screw for adjusting the length of arc. The screws J J, with large heads passing through the armature A, serve as adjustable pole-pieces, and can be secured by means of lock nuts, J^1 J^1. R is the dash-pot, and S S^1 are the binding screws. The current entering at the positive binding screw S passes through the insulated flexible wire or cable S^2 to the upper carbon holder C, from thence through the arc and lower carbon, and through the frame of the lamp to negative binding screw S^1. The side rods are insulated from each other, and the ends of the coils of the electro-magnets F F are connected to the binding screws S S^1, thus placing the electro-magnet F in derivation from the arc. When the lamp is ready for action the carbon points are separated by means of the spring acting on the armature lever. The current takes effect upon the electro-magnet, which overcomes the force of the spring, thus loosening the clip and allowing the upper carbon to fall by gravity into contact with the lower one. The main circuit is thus completed, the spring overpowers the weakened magnetism of the electro-magnet, whereupon the spring again pulls up the lever, and with it the carbon rod, forming the arc. As the carbons burn distance between them becomes greater, and the resistance in the main circuit increases. This causes more current to pass through the shunt electro-magnet, which, becoming stronger, again attracts the armature and lowers the carbon rod. The lamp gives a steady and regular light.

AN AUTOMATIC REGULATOR.

In this instrument, designed by Messrs. Walker and Olliver, the electro-magnet shown is placed either in circuit with the supply wire or in shunt, as convenient. Its armature, whose motion towards the poles is opposed by an adjustable spring, carries a carbon contact, which on the arrival of an excess E.M.F. sufficient to overcome the mechanical resistance



opposed to the pull of the electro magnet, makes more or less firm contact with another carbon point in connection with a variable resistance, forming an additional path for the current. By forming the variable resistance of one or more incandescent lamps, the regulation of the by-path is said to be very perfect. A slight increase of E.M.F. produces light contact between the carbons, while, only a small current passing through the lamp, its resistance is only very slightly lowered. As the excess E.M.F. increases, the resistance offered by both the carbon contacts and the filament of the lamp decreases until the limit is reached for which the apparatus is arranged.

DRY ELECTRIC BATTERIES.—This paper, by W. V. Beetz, contains a series of determinations of the electromotive force of certain dry forms of Daniell's battery, especially of those consisting of U-tubes containing in the one limb copper sulphate solution, in the other zinc sulphate solution, both being worked up into a paste by plaster of Paris, and then allowed to set in the tubes. Their use as an unit in electric measurements was examined; it was found that in some cases the difference of potential remained constant, whilst in others it decreased very rapidly. Such batteries cannot be used in electro-therapeutics.—*Jour. Chem. Soc.*

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THE ELECTRICIAN.

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All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

ANSWERS TO CORRESPONDENTS.

LEO.—*The only work dealing solely with secondary batteries is that of Gladstone and Tribe, published by Macmillan and Co. The literature of the subject is to be found in articles in various periodicals.*

CABLE.—*A letter awaits you.*

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1885.

(Continued from our last issue.)

In the ordinary course of events the snowstorm of Wednesday morning would have led us to discuss once again the danger of overhead wires, but we must content ourselves with a brief reference to it here. The Telephone Company since its inception has had no storm of any magnitude to contend against, and it may be thankful that even Wednesday's visitation was less disastrous than any winter might be expected to bring. Still, its effects were such as not to increase our respect for the shrewdness or business capacity of men who persist, against all advice, in following a system, or rather want of a system, which has nothing to commend it except the obstinate consistency of a speculative directorate. It will save the shareholders thousands of pounds if the storm of Wednesday is followed by another which breaks down every telephone wire in London. The time is rapidly coming when argument will be useless, and when the property will be valueless instead of valuable. The case can be put clearly and summarily in a few sentences. The Company has a large capital, a great part of which was paid for patent rights which will expire in a few years. Up to the present very little has been done to depreciate the capital account paid for these rights. The system adopted in the work—commenced in ignorance and continued against advice—is of such a kind that periodical breakdowns are absolutely certain. While everything is new these breakdowns may not be overwhelmingly extensive or expensive, but as the years roll on—say, about the time the patent rights expire—the London atmosphere will have done its work upon the wires, and during any winter storm a general breakdown may occur. What will the shareholders do then? Investigate and find that the "powers that be" hold few shares, having judiciously "got out" at the right time. We have said it before, we say it again, that the telephone system of London is not carried out so as to be a lasting benefit to the shareholders, and, further, the public suffers considerably from the uncertainty of the system. At one time we thought the Company intended to force the hands of Government, for all discerning persons must see that sooner or later the Government must take over the telephonic business of the country. The shareholders may rest assured that if what they have to sell, after years of monopoly, is valueless, the Government authorities will say so, and proceed quietly to do the work themselves. The constant aim seems to be to consider how to keep up or to get a higher quotation for their shares—not to make a good, sound, solid, substantial business, which future years will strengthen, and which attacks or opposition from within or without cannot hurt.

The strong views we have expressed from time to time in relation to telephony are said by those who should know better to be the views expressed by the Post Office officials, or the views of opponents to the existing company. Nothing could be further from the truth. The opinions are those of wholly disinterested critics, who, seeing one of the best applications of electricity—one of the most beneficial and useful to the business community—practically undeveloped, and threatening to become a white elephant to innocent shareholders, would force a change in the right direction while yet there is time. We shall now leave this subject for the present, and continue our account of work done in the past year by individual firms, adding some expressions of opinion upon the prospects of electrical applications generally

We have already referred shortly to the work of Messrs. Siemens, who, together with the Brush Corporation and Messrs. Crompton and Co., probably do the largest share of electric lighting work. Messrs. Crompton and Co. have during the year completely altered their design of dynamo, and have substituted the Crompton type of machine for that of Bürgin in all sizes and patterns. It is hardly necessary for us here to say more than that the Crompton type is more nearly akin to the Gramme than Bürgin. This firm has been fortunate enough to keep their works fully employed, and, in fact, have been able to keep a night gang going throughout the whole of the year. During the early part of the year they finished the fitting out of the Brazilian ironclad "Aquidaban," and made six sets of search light apparatus, including engines, dynamos, projectors, &c., for the new type of sea-going torpedo boats in H.M. Navy. They also manufactured search-light apparatus for H.M. ships "Black Prince," "Shannon," "Scout," "Landrail," "Curlew," "Caroline," "Royalist," "Acorn," and three others; and also manufactured for the Admiralty twenty-eight sets of search-light apparatus for store. The firm has carried out complete installations at Sir John Fowler's house, Braemore, on the training ship "Exmouth," the Birmingham Liberal Club, for the Mersey Docks and Harbour Board, for the Meisenbach Company, for the Royal Institution, for the East and West India Dock Company, and others. They supplied dynamos and apparatus direct for the lighting of Buckingham Palace, for Lord Bute at Cardiff Castle, for Sir David Salomons, and many others. In addition to these, through their various

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agents, Messrs. Bennett and Co., J. P. Fearfield, W. Hartnell, Holmes and Vaudrey, J. C. Howell, H. Lea, Muir and Mavor, &c., they supplied nearly a hundred dynamos, as well as various other apparatus, to form part of installations in different parts of the country. They have in hand, and nearly complete, a very heavy contract for the Imperial and Continental Gas Association, consisting of dynamos, steam engines, &c., for electric lighting at Vienna. They have also in hand a large contract, for the East and West India Docks Company, for the complete lighting by electricity of the new Tilbury Docks, which, when complete, should be one of the largest contracts as yet carried out. Messrs. Crompton and Co. have during the year brought out some notable improvements in the construction of search light apparatus by the use of the Carver mirror, in place of the Margin projector, hitherto employed in Her Majesty's Navy. They have also designed and are executing an order for the lighting of a lightship belonging to the Mersey Docks and Harbour Board. Such reports as these strengthen our remarks as to the gradual progress of electric lighting.

Mr. J. H. Greenhill, of Belfast, has during the year carried out six new installations, and increased the capacity of two existing ones, all in Ireland, the total of new lamps of 16 candle-power in these installations being, in round numbers, 1,000. This included a repetition order by one firm of a machine to run 500 lamps, which was built with wrought-iron magnets (all Mr. Greenhill's dynamos are now of wrought iron), which has been running since September without a hitch. There has been very little done in Ireland in arc lighting during the year, but some important contracts are to be carried out immediately. Mr. Greenhill believes the electric light is now decidedly recovering from the result of its partial collapse, and that it will go on by sure degrees, which will be all the more reliable, compared to the "hop-step-and-a-jump" progress made during the excitement of three years ago. The experience of the past year shows that the durability of the Swan lamps is immensely greater than it was before, and if they were only about half the price, it would aid in increasing electric lighting. This opinion is based on the belief that users would not object to the more frequent renewals of lamps, and they would elect to drive them at a higher candle-power, getting thereby a vastly superior style of illumination unattainable by gas. In order to save the cost of renewals, those who use the light now rather under-run the lamps, the consequence being that the degree of illumination is not to any material degree superior *in appearance* to gas. As a proof of this, Mr. Greenhill mentions a client whose shop has been lighted by incandescent lamps for two years; but scarcely attracted any attention till he decided to put in a new machine of larger capacity, and to increase the number of his lights. This was done, yet it was when he elected to over-run his lamps (each giving a light of about 25 candles) that the difference in the appearance of his shop attracted attention, and the footpath and interior of the premises were blocked with people. Although he has been over-running the Swan lamps to this extent, he has not had a lamp give way for the three weeks he has tried it.

We may here interpolate Mr. C. Lever's opinions as to the present and future prospects of electric lighting. This gentleman has not only studied the question from a theoretical point of view, but has had great practical experience, and has visited America during the past year in order to see exactly what our cousins across the Atlantic were doing. He writes as follows:—

"When shall we realise the bright prospects which the promoters of electric lighting schemes put before the public in 1882? The fact is that those 'castles in the air' have long since disappeared, and as we enter the year 1886 we are found still grappling with a new industry. That the electric lighting industry has grown no one can doubt. The increase of electric lighting installations and orders for extensions go to prove this. But, whilst the demand is on the increase, it should be remembered that the supply is still very much in excess of this demand. Unless, therefore, the general depression of trade clears away, we must expect to find more defunct electric lighting companies during the present year. Last year saw the extinction of the Hammond Company, and the electric plant which was purchased at the sale by auction now makes its appearance in a market already glutted with the apparatus of fierce competitors, and at prices for which the apparatus could not possibly be manufactured. These are gloomy prospects, and although we are told over and over again that 'every cloud has a silver lining,' it must be owned that this 'silver lining' is a long time in making its appearance.

"I see no reason to depart from my opinion expressed at this time last year, viz., that arc lighting offers the widest field for the electric light engineer. To some it may not seem so, but this opinion has been strengthened by many recent observations. It is the only light in this country that can compete with gas. Indeed, the arc light can do more, for it can afford a better light than gas light, and at a less cost. And although we cannot place an arc light in a drawing room, we can do a great deal more than we are doing with small arc lamps. In engineering works, foundries, railway stations, goods warehouses, sidings, colliery pit banks, &c., arc lighting has supplied a long felt requirement. It would be absurd to attempt to light such places by incandescent lights. There have been attempts to do this, and they have invariably resulted in failures. The lighting of a railway station on the incandescent system is madness, for the place could be lighted much cheaper by gas. Even in large picture galleries there is considerable scope for arc lighting, if the lamps are really steady, reliable, and not too powerful. A few years ago I saw a picture gallery lighted by arc lamps of 800 candle-power each, and the other day I walked into a picture gallery lighted by 20 candle-power incandescent lamps. There was no comparison between the two; in fact, I heard complaints that the incandescent lamps were so placed as to be most disagreeable to the eye, and people went away with the headache. I never experienced this in the former place, lighted by the arc lamps, and I never heard any complaints to this effect, although I must say that the arc lamps were not as steady as they ought to have been. Now, I do not for one moment infer that all picture galleries ought to be lighted by arc lamps. The incandescent light is an expensive light, but it has its sphere of usefulness. Every steamship, every flour mill, and every coal mine ought to be lighted on the incandescent system. Its safety alone is a recommendation. But there are so many instances in which the lights are misplaced—where incandescent lamps are installed instead of arc lamps, and arc lamps instead of incandescent lamps. Let me give an illustration. I know a theatre lighted by incandescent lamps. In the *sunlight* over the auditorium are about 250 lamps of about ten candles each. The machinery is big enough to light a small town, and yet it never seems to have struck the electric light contractors that one good arc lamp would require one-tenth of the power, and give the same amount of light. Of course, when our lighting supply stations are erected—when electricity is laid on as gas is at present—we shall be able to please ourselves, and have our arc lamps or incandescent lamps fixed with the same ease that we can now have our Bray, Sugg, or Thorpe and Tasker's gas burners fixed. That will be electric lighting."

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We will now consider the work of a firm away from the metropolis—that of Messrs. Walker and Olliver, of Cardiff:—

In January this firm opened a branch at Newcastle-on-Tyne, and in the following June removed the Midland branch from Nottingham to Leeds. They have had the usual mining signal work in all parts of the country, but principally in the South Wales district, where the past year has seen the conversion of several of the older firms, who adhered to the old method of signalling, to the electric system. In fact there is hardly a firm of note now in the district which has not adopted electric signals, and these signals are in all cases a great boon. Some of these underground signals have circuits several miles long. This would, of course, be nothing on the surface, but it is a great deal in a mine. South and West Yorkshire and Scotland have also adopted electric signalling; but Northumberland and Durham have only partially adopted it, and Lancashire hardly at all. In many cases, suggests Mr. Walker, the adoption has been delayed by inefficient work in the first instance; cheap bells, cheap batteries, cheap wire, and when a signal breaks down managers are apt to blame the system, and not the work.

With regard to telephone work the firm has done absolutely nothing. Mr. Walker says, "The action of the United Telephone Company in blocking up all sources of supply, and in annoying every one who uses a telephone which is not paying them a royalty, has pretty well rendered this department not only unprofitable but a serious loss. Considering the delicacy of telephonic apparatus, the training necessary to enable a man to quickly repair the numerous trifling faults that are constantly occurring, even with the best apparatus, and the trouble of way-leaves, it only needed the additional spur of the merciless persecution to which we have been subjected to make us decide to have very little to do with it until the patent has expired, or until some one brings an instrument into the market that shall be as good as the Edison-Bell combination, using the term in its full legal sense, and that shall be able to hold its own legally, and whose owners shall be willing and ready to withstand all attacks, and to protect its users and agents. At present, unfortunately, this does not exist. The instruments of Prof. Silvanus Thompson, though, as far as one can judge, free of the so-called master patents, and backed by a strong company, have not, so far as our experience goes, got over the initial manufacturing difficulties that often beset a new form of apparatus. The fault in this case, in our opinion, has been in endeavouring to make the instruments too cheaply. If the profit required would not allow of more careful work, it would have been better to have added £1 or £2 to the selling price, and have put that amount extra into the construction."

In electric lighting Messrs. Walker and Olliver have been more fortunate. In April they carried out an installation of four arc and forty incandescent lamps at the New Elliot Pit, belonging to the Powell-Duffryn Steam Coal Company, of which Sir George Elliot is chairman, this being the second colliery lighted for the same company, and a third is in hand, to consist of three arc lamps and fifty incandescents. In each case both arcs and incandescents are worked from a compound shunt-wound Gramme dynamo, the arcs being in parallel circuit with the incandescents. In July an installation of seventy incandescent lamps was carried out at the Elemore Colliery, belonging to the Hetton Coal Company, this being the third contract executed for that firm. The lights are used to illuminate four seams about sixty yards apart, the dynamo and engine being in the top seam, and wires led to the others. The arching and roadways are whitewashed as far as possible, and the effect is very good indeed. The difference between walking about in one of these collieries so lighted, and a colliery lighted even with gas, is quite as great as between a country road, on a dark night, and a *gas*-lighted street. The lights are not carried into the workings, but are taken well along the main roadways for several hundred yards, and into all engine houses, stables, &c., switches being placed to turn the lamps out when not required. The dynamo and engine run day and night from early on Monday to Saturday, stopping morning and evening, as usual with all engines in collieries, for examination, when the brushes are trimmed if required. The three installations at these collieries are with old Gramme machines; that is, with the wood hub so much condemned, with which, though taking a larger density of current than Mr. Kapp and Mr. Crompton would allow, running at a higher surface speed, and for longer hours than is usual under harder conditions, there has been scarcely a hitch the whole time they have been running. Two of these dynamos are running the third and fourth winter respectively. Leaving out the convenience, the safety and the beauty of the light, the company have realised a large saving in gas fittings alone since its adoption. At the meeting of the South Wales Institute in November last, on the discussion of a paper on "Improvements in Electric Lighting," the general manager of the Powell-Duffryn Company's Collieries, who hails from Durham, stated that he had had his collieries carefully costed, where gas, oil, and electric light were used, and that though oil came out cheapest, the electric light was not far beyond it, while gas was double the latter. His conclusion was that, taking into consideration the convenience of the electric light and the amount of light obtained, it was far and away the best form of illuminant for collieries.

Recently an installation of 50 incandescent lamps has been put in one of the Babbington Collieries, near Nottingham; an installation of six arc lamps and 90 incandescent lamps at new Herrington Colliery for the Earl of Durham. These are for the surface, and are worked from one dynamo as before. An installation, consisting of thirty incandescent lamps, with provision for more, and a separate dynamo is being carried out at the same colliery underground to light the pit bottom, main roadways, stables, engine houses, &c. The dynamo and engine are placed underground, plenty of steam being available. An installation is nearly completed, consisting of eight arc lamps and forty incandescent lamps, at the Windsor slipways, Cardiff. There are two long jetties, one on each side of the double slipway, the latter being arranged to take in two ships at the same time. There are four arc lamps on each jetty, and reaching up to abreast of where the ships are when out of the water. The fitting shop, joiners' shop, engine houses, stores, &c., are all lighted by incandescent lamps, the same system being adopted as already explained. The switches for the arc lamps with this arrangement are usually placed in the engine house, but of course they can be fixed at any convenient point. The most notable feature the firm claims for the year in connection with electric lighting work consists in the adoption of a system, carefully worked out, of running arc and incandescent lamps from the same machine, a compound shunt-wound self-regulating dynamo. The arc lamp used is the old "Brockie" mechanical commutating lamp, but without its feed wire and without the revolving circuit-breaking commutator.

The lamp has a single electro magnet, and just one or two clutches, according as it is a single or double lamp, with the usual guides, &c. The wire of the electro-magnet is in the same circuit with the arc, and wired with the gauge required to take the current intended for the lamp, a matter of very simple calculation; so that lights of varying power can be used.

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Thus, in a large open space a large current is used, in a confined space a small current, getting the best results all round. It is found that by cutting down the current a greater economy in carbons is obtained. Where a pair of carbons used to last six hours they now last twelve hours. In connection with this, it is advantageous to use carbons as large as possible to a certain limit, so that all the work done is inside the arc, and very little glowing carbon outside. We find that there is less liability of the carbons sticking, as they do not tend to soften so much, should they accidentally drop into contact, than where you have two or three inches of glowing carbon outside the arc.

For results, with 13mm. carbons, 6 ampere current, 35 volts across the terminals of the lamp, a light is obtained that will enable one to read a newspaper at 40 yards when the lamp is 20ft. above the ground. Both arc and incandescent lamps are perfectly steady, and the feeding of the arc lamps, no matter how many there may be, has no effect upon the light given by the incandescents. A little consideration will show that this is only as it should be, since an arc burning long, or going out by breaking circuit is merely equivalent to turning out a certain number of incandescent lamps, and an arc burning short or running into contact is equivalent to the reverse.

The rationale of the working of the arc lamp Mr. Walker suggests to be as follows:—"You start with a certain E.M.F. at terminals of machine, a certain E.M.F. at terminals of lamp, less, of course, than that at machine, a still lower E.M.F. across carbons. Now, supposing the E.M.F. at terminals of machine to remain constant, the arc increasing increases the resistance, weakens the current, and raises the E.M.F. at the arc, so that you have the two things—current weakening, tending to allow your top carbon to fall, and E.M.F. rising, giving increased power to maintain the arc. The result is a beautifully steady light, and I think the lamp can hardly be beaten for simplicity. The early arrangement gave each arc lamp two wires direct from the machine; but later a return large main for several arcs is used, giving each arc its own positive main, in which is inserted a resistance variable at will. The arrangement seems well adapted for a large number of industrial purposes, where it is of advantage to have an arc light in certain places without the trouble of a special machine; and it must certainly bear the palm for simplicity. The one feature against it is the extra length of wire used; but, in practice we do not find that serious, as by placing the dynamos in a fairly central position the actual length is much as usual, and working with smaller currents we are able to use smaller wires."

Several improvements have been made in the Gramme machine, small perhaps in themselves, but often bearing very important results in the matter of wear and tear and output. Thus modifications and alterations have been made in the pattern and construction of the brush holders and terminals, the quantity of iron in the core, and the winding of both armature and field magnets. The output has been largely increased by these modifications with ease and perfect safety.

Automatic regulators have been designed and introduced. The regulator is designed to compensate for the pulsations of a gas engine, and to replace the somewhat barbarous plan of fusible cut outs—which, by the way, often do not cut out when they ought—by throwing in either an artificial resistance, or by opening a by-path to carry off the surplus current.

A current meter has been designed to count in a simple manner, in any units that may be arranged, the product of current and E.M.F. actually expended during a given time in any place over which the meter has control.

We shall now give Mr. Walker's opinion as to the prospects of electric lighting in almost his own words. He says, with regard to the future of the electric industry generally:—"I am *very* hopeful indeed. In spite of companies breaking, and all the money that has been squandered in floating them having been wasted, electric lighting at least has been steadily advancing in a quiet unobtrusive way. Firms and individuals who some six years ago would have laughed at the idea of adopting the electric light are now, in many cases, using it, and wondering how they did without it, and many others are now convinced that there is something in it, and are determined to adopt it if they get another shilling on the coal, another pound on the iron, &c. It is very doubtful if the shilling or the pound will come; prices rarely go back; but they will have the light all the same, and for this reason. Sooner or later they will cease to look out for an advance in prices—more probably they will have to face a further reduction—and then the question comes, How is a margin to be made between cost and selling price? There is only one answer to this, and it has been given in days gone by over and over again. Wages cannot be reduced beyond a certain limit, and the only resource is increased productiveness of machinery. In this, electricity will play an important and ever-increasing part. To lessen waste is to increase production; and in many cases to give a better light is to lessen waste, or to give greater facilities for manipulating. Again, the work value of the human machine, whether it use its hands or its head, whether it be male or female, depends on the state of its health; and the state of its health is very largely dependent upon the atmosphere in which it works. How often are the seeds of consumption sown in passing out of a hot stifling room into the delightfully refreshing, but deadly cool atmosphere outside, and this no matter whether the hot room is a ball room or one of the flats of a factory? The ball room belle can lay up, while illness to the poor factory girl means privation, if not starvation. How many broken threads, spoilt stockings, spoilt curtains, wasted yarns, &c., are due to colds caught in this way; and how many would be avoided if factories were lighted with incandescent lamps, which can be taken inside the most delicate fabrics without injury, and that show all the colours true as they are by daylight. And how many ruined eyes may we place at the door of flickering gas and vitiated atmosphere? Again, are not arc lamps distributed down back streets and in dark lanes better than policemen?

"But that is only one branch, though an enormous one. I have a firm belief that it is as certain as anything can be in this world that the electric light will supersede gas for illuminating purposes. It has many difficulties, and it will take time, but it is sure to come. Gas, which even at this day, if we examine it dispassionately, is really a barbarous method of illumination, was looked upon as the invention of a madman when it first came out. Once have the electric light in house or factory, so that it is as reliable as gas, and the user would never go back. Gas superseded candles and the old oil lamp, not because it was cheaper—it is not by a very long way—but because it is more convenient, certain, and far safer.

"In my opinion, it would be well for the electric lighting companies of the future to commence in a small way, and work up. They will always be able to get capital if they can show dividends. Then as to the future of electrical engineers, I see no reason to be depressed in this matter. At the present time, no doubt, there are many who have been employed in electrical work who are seeking work; but are they all *bonâ fide* electrical engineers? Are not many of them men who have gravitated into electrical work because a few years ago high salaries were paid, or because they thought electrical work was easier and more

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genteel than work they were doing? I believe myself that the demand for trained electrical engineers must soon increase, to keep pace with the requirements of the rapid advances that are being made; and I should be very sorry to say a word against men already skilled in one profession gravitating into ours. The union of mechanical and electrical engineering, or of chemistry and electrical engineering, must be of great advantage to the profession finally adopted, provided the latter be honestly, carefully, and patiently studied and practised. Unless this is done, the so-called electrical engineer will do harm and bring the profession into contempt by the blunders made. It appears that there is too great a tendency to think, as a local ironmonger told me, that 'there is no mystery about electrical engineering.' A man who has purchased a bell and battery and a few yards of wire at a shop, and has succeeded in getting them to work, and who, perhaps, has a few crude ideas on the subject, straightway dubs himself an electrical engineer, and will take a contract to execute anything, or will offer himself for any kind of work, under the impression that he is quite sure he can do it if he tries. There is only one way to acquire a sound practical knowledge of electrical work, as of anything else; and that is by years of careful study, backed up by actual practice, actually doing the work. No school or college course of a few months, however well appointed the school or the college may be, can ever be more than preparatory to practical work. It is undoubtedly a valuable preparation, but no more; and young fellows whose means will allow it would do well, after passing through these schools to article themselves to some good firm where they can acquire the necessary manipulative experience. Another point may be suggested. Is the work developed enough to divide electrical engineering into separate branches, and to have telegraph, telephone, electric light, &c., engineers trained in their own particular division, and knowing little of any other? I would most strongly advise young fellows who aspire to become electrical engineers, to train in all branches, and to lose no opportunity of studying or practising all branches of the subject. They will find that the broader the basis of their knowledge of the subject, the greater the mastery of each part of it, and the more valuable to the individual. Moreover, in electrical work, one can never tell what is coming next, and an exclusive training in one branch is a great drawback, should one be thrown accidentally or temporarily into contact with another branch. Telephone work, for instance, necessitates the training of the mind to grasp the idea of very minute currents, and the whole of the apparatus in connection with it is small and delicate. A small particle of dust interposed between two surfaces in contact or a layer of lacquer, and the instrument is out of order. On the other hand, in electric lighting the opposite conditions hold good. Here we have large currents, high E.M.F.'s, and many H.P.'s transmitted. A mastery of both materially assists one in discovering faults in either, but a training exclusively in one almost unfits a man for work in the other. The man who has spent his time solely in electric light work cannot appreciate the delicacy of telegraph and telephone work; and I have found the greatest difficulty in getting a highly-trained mechanic who had been accustomed to submarine work into electric light work. For a long time the tendency is to put delicate springs where perhaps half-inch brass was required.

"The advice given to all desirous of entering the profession is, learn to do, as well as to tell others to do; be able to use hands and brains; and regrets will never arise from such a state of things. Suppose, for instance, a telephone is out of order, the company is written to, and an inspector arrives. If the fault is a trifling one, as it very frequently is, it would be to his own interest, to that of the user and his employer, to put it right there and then. A dirty connection wants cleaning, a screw out of regulation, a drop of water in the battery, and so on. If, however, he appears in kid gloves, with a very delicate instrument, perhaps measures various resistances, and ends by sending someone else, there is delay and expense, and, if it occurs frequently, annoyance all round.

"This bears on what I am about to say as to the field for electrical engineers in the future. Irrespective of companies and firms manufacturing electrical apparatus, or selling electricity in one form or another, as the large industrial firms gradually adopt one kind of apparatus after another, they will be obliged to have their own electrical engineer, who will be an important man about the works. Every firm of any standing now has its mechanical engineer, who has charge of all the machinery, superintends the erection of new plant, &c. Many firms have now also an electrical *man* of their own. In most cases, at present, he is a working man, because the apparatus used is not of sufficient extent to warrant paying much for looking after it, and for designing or for advice in purchasing. This man is usually well paid, and has a fairly easy time, provided that he keeps things going. As time goes on, however, there will be more and more cases where he, having done his best, is beaten simply because the work is beyond his knowledge, he having only what is known as rule of thumb knowledge; hence, a professional electrical engineer must be called in. Ultimately the temporary assistance becomes permanent. His position, and his advancement will depend upon things going well. Managers and owners meet and confer together. 'How does your electrical engineer go on?' 'Oh, very well; we never know what a break down is since he came, and if we want to make any alteration or to put up any new apparatus, all I have to do is to tell him what I want. He brings me the order to sign, or gives his estimate, and that is all I know till I see the thing working. If anything goes wrong he's there quickly.' I think it may be safely prophesied that if this man wants a rise of salary, as the work increases, he will get it.' 'And how does he keep things going so well?' 'He examines everything himself personally every now and then; and if he is at a particular place, and sees some little thing, say a wire loose or dirty, a dirty terminal, &c., he does not sit down and make a long report, he takes out his knife and cleans it, or screws the wire up.' But, on the other hand, suppose it is this which the manager replies:—'Oh! he seems very clever, and can talk very well, but I am afraid we shall not be able to keep him, he is so expensive.'

"There is an important branch of electrical engineering at present almost untouched—viz., transmission of power. How easily, and how quickly, and with how little occasion for repairs, can two cables be laid, in almost any position, for mines, ironworks, docks, factories, as compared with shafting, ropes, steam pipes, compressed air. I have every confidence that the day will come when shafting and belts in factories will be looked upon as a barbarism, and people will wonder however they endured it so long. Numerous cases will occur to every one where cheapness and facility of working would result from the adoption of electric transmission. You have a ship in the dry dock, and want to drill a hole in her side; take a couple of wires down, a few minutes' work, and attach them to a motor that a man, or at most two, if the work be large, can carry. It may be objected that all I have said applies to the future. A good deal does, but not all, and in this work the future of to-day is the present of to-morrow. Ten years ago I was laughed at for proposing electric signals in mines; to-day the system is almost universal in cer-

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tain districts. Ten years ago there were absolutely no electric lights in practical use in England, except that in Dungeness Lighthouse; now look around you. Ten years ago there were few electric bells used—they were appreciated, but found to be always out of order; now they are the rule, and are rarely out of order. There is only one branch in which the hand has gone back, and that only for a time. Perhaps the greatest injury which the United Telephone Company have done, by the use they have made of their monopoly, is in stifling all improvement; and a second in shutting the door of an important branch of the science to the coming electrical youth. If the telephone were free, there is no other branch that would confer a greater boon on society at large, on manufacturers, and on electrical engineers, nor that would receive more rapid development and improvement. It is to the discovery of the telephone mainly that we owe the great and rapid development since 1877. To those whose heart is in the work I would say, in conclusion, master your subject, take every opportunity of studying and practising it, and for the rest, go on and fear not."

CORRESPONDENCE.

THE TRANSMISSION OF POWER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read in the last number of your esteemed journal a small paragraph which I cannot allow to pass without protest.

The writer of this paragraph makes me say that:—"To M. Marcel Deprez must be given the honour of being the pioneer in the application of electricity for this purpose" (transmission of power). If you will look carefully through all the numbers of *l'Electricien* published during the last two months, and particularly that of the 26th December, 1885, you will be convinced of the mistake made by your contributor.

I have said quite the contrary to the above, and have shown by means of figures and dates that M. Marcel Deprez comes in a good last, with machines which are the heaviest known at the present moment, and which, for a given power, show the greatest expenditure in excitation (18 per cent.)

I hope you will be kind enough to insert this notification in your next issue.—Yours, &c., E. HOSPITALIER.

6, Rue de Bellay, Paris, January 2nd, 1886.

NITRATE IN BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following is the solution generally used in nitrate of soda batteries:—

1. Water 7oz., soda 3, sulphuric acid 2oz.
2. The acid is generally added to the solution of nitrate.
3. I should not advise the use of bichromate of potash, as it increases the cost of working, and in my hands gives no better results.—Yours, &c., L. L.

81, Avenue-road, N.W.

AN ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Apart from the quaint way in which the subject is written up, there is nothing new in the *Daily Telegraph* account of the Electric Boy. It is well known in America and other dry climates that the friction of the soles of the feet on a carpet, even the act of quickly pulling off silk stockings from the leg, may generate enough electricity to produce sparks, sufficient, I believe, to light a gas jet. The hard horny foot of the negro, like the skin of the cat, is specially adapted to this purpose; and your correspondent incidentally names the carpet and the bare feet. Prof. Dewar's experiment with the galvanometer is of entirely different nature. It is originally due, I think, to Dubois Reymond; certainly it is given, with a large woodcut, in a manual of physics over twenty years old. I myself demonstrated it before the Physical Society in their first session, now many years ago. The deflection caused by contracting muscle is not easy to explain. Probably it is thermo-electrical; certainly it is purely adventitious, and not connected in any way with nerve force, or physiological currents.—Yours, &c., WILLIAM H. STONE.

DYNAMO TESTS.

(Continued from page 158.)

METHODS OF MEASUREMENT.

Measurement of Resistance.—For the standard resistance, a ten B. A. unit coil by Elliott, which had been compared at the Cavendish laboratory, and was used by Prof. Rowland in his recent determination of the ohm, was employed. The values of the resistances in terms of this coil were reduced to the Paris ohm, by dividing by 1·0112.

The bridge used in the comparisons was built at the Univerity Workshops, Cambridge, England. Its fixed (equal) arms were connected by a platinum silver wire bent in a circle, and their ratio changed by making contact with the galvanometer circuit at different points on the wire. Beside the wire was a scale, and on the arm carrying the galvanometer contact, a vernier reading to tenths of a division. When the fixed coils were each one ohm, a whole division of the scale meant a change of one part in 10,000 of the ratio, while with the galvanometer used, a change of one-tenth of a division or one part in 100,000 could be detected. The bridge had been calibrated for use in the determination of the ohm. With fixed coils of one ohm, the range of the instrument was about 10 per cent., so the resistances to be compared were always approximately equal. The different coils to be compared were balanced against resistances taken from "comparators," designed by Prof. Rowland. Each of these consists of ten coils of equal resistance wound together on a copper cylinder, the whole being coated with wax or paraffin and put inside a larger cylinder, the space between being filled with feathers. At the top the cylinders are separated by an annular sheet of hard rubber, around which two circles of ten holes each are bored for the terminals. The ends of each coil are taken to copper blocks screwed firmly beneath opposite holes in the two circles. The tops of the copper blocks are thoroughly amalgamated and the holes partly filled with mercury, connections being made by short U-shaped copper rods. Three comparators of 10, 100, and 1,000 ohms were used, giving a range of from one to 10,000 ohms. Each coil of the 10-ohm comparator was balanced directly against the 10-ohm standard, then the ten coils in series were balanced against each of the 100-ohm coils, and finally the 100-ohm comparator in series compared with each of the 1,000-ohm coils. In the measurements, the inner cylinders of the comparators were filled with water, and the standard immersed in water, the temperatures being noted. The zero of the bridge scale was taken as the mean of the readings when the resistances being measured were reversed. In measuring the resistance boxes, they were kept for six or eight hours in a room whose temperature was nearly constant, and then balanced against corresponding resistances taken from the comparators, the temperatures being, of course, noted. The coil for potential measurement was immersed in turpentine, its temperature recorded, and its resistance measured as above. The resistances compared at the Johns Hopkins University were the box for current measurements, the coils and bridge for measuring resistance, and the coil for potential measurement.

Measurement of Potential.

The galvanometer used for potential measurements was by Hartman. It was furnished with a Siemens bell magnet, closely surrounded by a solid copper block, and damped very readily, only making two or three swings before coming to rest. The

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suspension was a silk fibre about fifteen centimetres long. The coils, specially wound over the regular winding of the instrument, had a resistance of about two ohms. The galvanometer was in a circuit with resistances that were varied from 1,000 to 150,000 ohms, taken from boxes, two of 100,000, one of 10,000 ohms, the former by Elliott and Breguet, the latter by Bergman. All calibrations being made with the (30,000 + 20,000) Elliott coils in the circuit, it was necessary to compare the other resistances with these coils. The arms of the bridge being made equal, the (30,000 + 20,000) and (40,000 + 10,000) Elliott coils were balanced in succession against the 50,000 Breguet, resistances being added to one or the other until there was no deflection of the galvanometer. It was found that

50,000 Breguet = (30,000 + 20,000 + 280) Elliott.

50,000 Breguet = (40,000 + 10,000 + 250) Elliott.

The (30,000 + 20,000) ohms Elliott was also measured in terms of the bridge coils, and the value found, 49,960, was so nearly correct that in getting the ratios of the 1,000 and 2,000 ohms Bergman—used in measuring armature resistance—to the (30,000 + 20,000) coils, it was assumed that their values in terms of the bridge coils were the same as if measured in terms of the (30,000 + 20,000) ohms. The deflections were read by a telescope and scale, the latter by Browne and Sharpe, graduated to centimetres and millimetres. The distance from the telescope to the mirror was two and one-half metres.

Calibrations.—The galvanometer was calibrated, both by measuring a current passing through a standard resistance at whose terminals the leads of the instrument were connected, and by the difference of potential at the terminals of a calorimeter. The constant was also checked with that of the current galvanometer, after each test, by measuring the current through the German silver strips used for the external circuit of the dynamos, and the potential at their extremities. During the tests forty calibrations were made, thirty-six with the silver voltameter and standard coil, and four with the calorimeter. The constants determined by the calorimeter agreed so closely with the measurements by the voltameter, and the labour both of observation and calculation in the former was so much greater than in the latter, that it was thought unnecessary to make the observation any oftener.

Voltameter Calibrations.—The current used varied from one to one and one-half ampere, giving a difference of potential at the terminals of the standard coils of from twenty to thirty volts. The coil shown in Fig. 2 was of No. 22 German silver wire, wound on glass rods fixed in a wooden framework. The turns were kept apart by silk cord wound on the rods. The whole was immersed in a high grade oil (300° fire test) kindly furnished by the Standard Oil Company. The oil was constantly stirred while the current was passing. The measurement of the resistance has been described. Its value was 21·161 ohms, at 14° C. For measuring the currents, a silver voltameter was used, the anode being a spiral of silver wire wrapped in filter paper, the cathode a platinum crucible filled with a 40 per cent. solution of silver nitrate. The calibrations took from ten to twenty minutes, the deposit ranging from ·9 gram to 2· grams. The times were noted by a chronometer whose rate, + 1 second per day, was neglected. When the experiment was finished, the solution was poured out of the crucible; the deposit first washed with distilled water, then allowed to soak from one half hour to twelve hours, then washed again until there was no precipitate with a solution of sodium chloride, and finally slowly dried and then weighed. A double reading of the galvanometer was taken each minute, and the constant calculated from the mean reading for the time of observation. The constant is given by

$$k_{50} = \frac{C\,R\,(1+M_c)\,(t_c - 14°)}{2d} \left\{ 1 - M_b\,(t_b - 25°) \right\}$$

where

k_{50} = constant for (30,000 + 20,000) ohms;
R = resistance of standard coil at 14°;
t_c = temperature of standard coil;
M_c = temperature coefficient of standard coil;
M_b = temperature coefficient of box;
t_b = temperature of box;
$2d$ = double deflection of galvanometer;

25° being taken as the standard temperature of the box.

When other resistances were used in the circuit, the constant was multiplied by their ratio to the (30,000 + 20,000) ohms.

(To be continued.)

MAGNETISM.

BY WILLOUGHBY SMITH.

(Continued from page 149.)

If the iron rod be placed parallel with the earth's magnetic lines of force, it will become magnetised in the direction of its length, but if placed at right angles to these lines it becomes magnetised in the direction of its width; or, in other words, a magnetisable body becomes magnetised by induction from the polarised lines of the earth's magnetism in a direction parallel to those lines. The value for any particular position remains constant, so that, whenever the rod is placed in the same position, the same value is obtained, provided the rod has not been subjected to any mechanical agitation. It therefore follows that the magnetism induced in the rod may be varied or reversed by simply altering its position in relation to the earth's magnetic polarised lines. A few moments' thought and reasoning on the nature and results of this experiment may not be altogether without instruction.

Consider that a length of magnetised iron or steel of any form will, if at liberty to do so, always rest in a position symmetrical to the polarised lines of magnetic force emanating from the earth or from any other source. If, however, there are two sources of magnetic polarisation acting at the same time, then the iron or steel will take up a mean position. The iron and steel emit their own polarised lines of force, which, more or less, affect each other, endeavouring so to move the masses of metal from which they proceed as to permit of the lines of force emanating therefrom being, as nearly as possible, symmetrical to each other, and then all apparent influence ceases. In the case of the small magnet, freely suspended in the neighbourhood of the polarised rod of charcoal iron in the experiment before described, the rod of iron and the small magnet both sent forth their own lines of polarisation, causing the relative position of the two bodies to be so altered as to allow the magnetic lines of force emanating therefrom being symmetrical to each other, or, at least, as nearly so as the interfering earth's magnetic field permitted them to be. In this case it is only the magnet that moves, the rod being, for all practical purposes, a fixture. It follows that what is taking place when the iron rod is moved in the vicinity of the magnet in the manner before described is, that as the rod is moved the lines of force proceeding therefrom are also moved; consequently the position of the lines relatively to those produced by the magnet is changed, and the latter, being free to move, is influenced by its own lines of force, which change their position until they again become symmetrical to those of the rod, and thus the deflection of the magnet is caused. It has long been known that a magnetic needle, if suspended so as to be movable only in the vertical plane, will remain in a *horizontal* position at the magnetic equator; but, if gradually moved from that position either in a north or south direction, it will assume every degree of inclination until it reaches the magnetic pole, and there it will take up a *vertical* position. This is called the magnetic dip, and, as far as I know, no satisfactory explanation has been given to account for the phenomenon; but I consider it a beautiful illustration of the correctness of the hypothesis which I have above ventured to put forth.

In Diagram IV. I have endeavoured to better illustrate these lines of force and their effect on each other, as my imagination represents them. A, B, and C, show the positions assumed by the magnet in relation to the influence of the lines given out by the iron rod. As I imagine it, each atom contained in the rod of iron has its own polarising effect, consequently each atom forming the surface of the rod affects the atoms of the medium surrounding it, and, that being so, how inadequate must be the representation of those lines, which in reality must be more numerous than the most sensitive human imagination can conceive; in fact, the phrase "lines of force" is a mere figure of speech, used for the purpose of clearly indicating the direction of polarisation.

Dr. Gilbert, to whom I have already referred, was the first to discover, or at any rate to publish, the interesting fact, that the intensity of a magnet is altered when the iron or steel is affected by any mechanical percussion. To illustrate this, let the iron rod,

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as used in the last experiment, be in such a relative position to the magnet as to cause a certain deflection, it being understood that the rod is magnetised simply by reason of its position in the earth's magnetic field; and, while in that position, north and south, let one end of the rod receive a blow from any mechanical contrivance; the deflection will be then increased, and will continue to increase after each blow up to a certain point, after which no mechanical influence appears to affect its magnetism. In an actual experiment the maximum deflection was reached at the fifth blow, and the ratio between the maximum and minimum deflection was as 1 to 2·34; for instance, with the rod in a horizontal position, north and south, the deflection was 23·5, and after the fifth blow it was 55·, or 2·34 times the amount. On another occasion when the rod was in a vertical position the deflection was 64 divisions, and after the fifth blow 150 divisions, which is, as in the previous case, 2·34 times the original amount; the ratio of increase varies, however, with each specimen of iron, and depends upon its purity and dimensions.

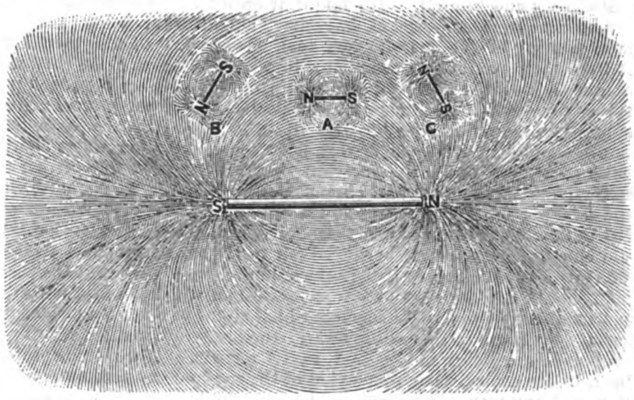

DIAGRAM IV.

The magnetism is not only increased by mechanical percussion, but the increase is to a great extent permanent whilst the rod remains undisturbed; but if its position be changed and it is again subjected to mechanical percussion, the previous magnetism will disappear and a fresh maximum value will be obtained, which is the maximum value of the new position. Mechanical percussion

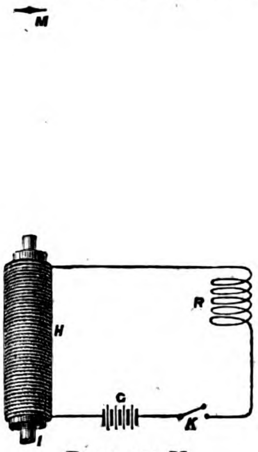

DIAGRAM V.

appears to affect more or less magnetism, developed in any known form; but, to arrive at definite and positive conclusions, a series of long and well-devised experiments must be conducted with extraordinary care and patience, as there exists such a variety of circumstances, each one of which, if neglected or overlooked, might vitiate the correctness of the results. The following experiment was made in electro-magnetism. A bar of round charcoal iron ·25in. in diameter, and 12in. in length, was annealed by being raised to a red heat and then allowed to remain undisturbed until the fire had died out and the bar become cold. Over a brass tube, ·31in. internal diameter and 10·5in. in length, was wound 520 turns of silk-covered copper wire, the total resistance of which was ·72 ohm. This helix was joined in circuit with a battery, a resistance and a key, as shown in Diagram V. H represents the helix and brass tube, I the iron rod, R a resistance which could be varied as required, G one Grove cell with an electromotive force at commencement of experiment of 1·92 volt, and resistance of ·23 of an ohm, K an arrangement for making or breaking the circuit, and M the small mirror reflecting magnet. The resistance R was at first adjusted so that the intensity of the current passing through the helix alone was only ·0019 of an ampere. The lines of force given out by the helix under these conditions, and their effect on those emanating from the magnet M were then noted. The circuit was then broken at K, and the iron rod inserted in the helix by placing it in the brass tube. The rod was placed at right angles to the magnetic meridian, for, in that position it was not sufficiently influenced by the earth's polarised lines of force to affect the magnet M. The circuit was then again made, and the deflection of M was as given in column A, Table I. While the current was flowing

TABLE I.

Current flowing through the magnetising helix. Amperes.	Deflection of the small suspended Magnet. A Normal.	B After mechanical agitation.	Ratio B/A
·0019	2·5	7·5	3·0
·0024	3·0	9·0	3·0
·0032	4·0	12·0	3·0
·0038	5·0	15·0	3·0
·0048	6·5	19·5	3·0
·0064	8·4	24·0	3·0
·0076	10·5	29·0	2·76
·0095	13·5	37·0	2·74
·0127	18·5	48·0	2·60
·0190	29·5	74·5	2·52
·0237	39·5	90·0	2·30
·0315	57·5	122·5	2·13
·0376	71·0	144·0	2·03
·0468	93·5	176·5	1·88
·0533	112·0	203·0	1·81
·0619	136·0	234·0	1·72
·0738	178·0	278·0	1·56
·0914	231·5	351·5	1·52
·120	331·0	465·0	1·40
·148	424·0	570·0	1·34
·174	521·0	664·0	1·27
·214	661·0	811·0	1·23
·276	865·0	1044·0	1·21
·388	1254·0	1458·0	1·16
·486	1625·0	1813·0	1·12
·651	2149·0	2349·0	1·09
·985	2850·0	2944·0	1·03
2·021	3391·0	3426·0	1·01

the lower end of the rod was repeatedly struck until the maximum deflection of M was obtained, which is given in column B, of the same table. After each experiment the iron rod was demagnetised, and the deflection caused by the helix alone for each current deducted from the values given. The current was then increased and the experiment repeated and so on, the results being all recorded in the table. The energy of the mechanical percussion necessary to increase the value in column A to that given in column B increases with the intensity of the current flowing, and therefore with the intensity of the magnetism induced in the rod; and it will be seen by reference to the table that the greatest increase due to mechanical agitation is obtained when the bar is only very feebly magnetised. If the generally accepted theory be correct, a rod of iron becomes magnetised in proportion to the intensity of the magnetic field in which it is placed, unless it be near the point of saturation, and, as the magnetic intensity is proportional to the current flowing through the helix, it follows that the rod should become magnetised in proportion to the current flowing; in other words, ten times the current should produce ten times the magnetism. The values given in column B approach closely to that law, except when the rod is near saturation, but not so the values in column A. It may be assumed, I think, that the values in column B are the more correct; and that with low magnetising power, mechanical percussion is necessary for the production of the true amount of magnetism corresponding to the inducing power.

I have already pointed out that it is necessary to observe great caution in manipulation, to avoid arriving at false conclusions while endeavouring to ascertain the existence, and true direction, of the lines of magnetic force of a body while under the influence of the earth's polarised lines of magnetic force; and this precaution applies, even more forcibly, when making similar experiments with an iron ring or disc. A rod of best charcoal iron ·25in. in diameter was welded into a ring 3·8in. external diameter and made red hot, and while in that state was laid on a sheet of asbestos and slowly revolved in a horizontal plane until cool. This mode of cooling was necessary, for experience had taught that if the ring remained stationary while cooling, slight, but fixed polarity manifested itself at the parts of the ring facing north and south, but that if it were revolved, as mentioned, whilst cooling no fixed polarity was manifested; therefore, when the ring was placed horizontally, so that the small magnet was in a direct line with the centre of the ring, no deflection of the magnet occurred, and although

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the ring was revolved while maintaining the same relative position to the magnet, still no deflection could be observed. It might be assumed from this that no line of force were being given off by the ring, but a little thought on the subject will, I think, prove such an assumption to be incorrect. The polarised lines of the earth's magnetism affect the polarised atoms of the iron ring in their own direction, north and south; consequently the lines given out by the ring are symmetrical with those emanating from the small magnet, and, as I have already shown in the case of the iron rod, no apparent effect is developed, and it therefore follows that this condition would not be altered by revolving the ring, for, as it possesses no fixed polarity, the poles would be continually in

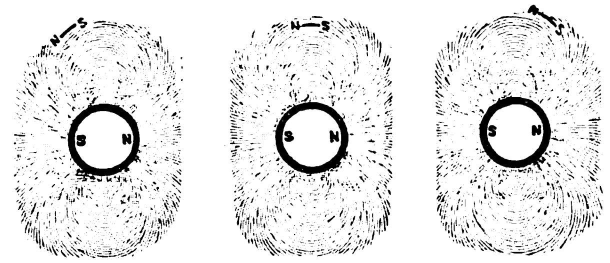

Diagram VI.

the parts facing north and south. But if either side of the ring be brought in line with the centre of the magnet, then the positions of the polarised lines relatively to those of the magnet are altered, and, as already explained, the magnet is deflected as illustrated in Diagram IV. A plate of iron, circular or of any other form, behaves in this respect precisely in the same way as the ring. The magnetic intensity in either case is increased, and definite polarity defined by a slight blow; even the flick of the finger is sufficient to produce an effect. Increase of temperature produces precisely the same results as a blow from any mechanical means. May we not, therefore, say that what we designate heat is the cause in each case, for it is well known that a few well-directed blows on a rod of iron will considerably increase its temperature?

It was thought that perhaps more accurate results would be obtained if the influence of the earth's polarised lines of force could be eliminated as regards the measuring magnet; therefore, a glass tube 20in. long and 2in. internal diameter was fixed in a wooden base B, Diagram VII.; C is a wooden cap fitted in the top of the

Diagram VII.

tube. By means of a glass hook fixed in the centre of the cap was suspended, by a very fine silk fibre, the two small magnets marked S—N, N—S, which were rigidly connected by a fine glass rod, R. The intensity of the magnetism in each was such that the couple was apparently unaffected by the earth's magnetism. A rod of charcoal iron 10in. by ·3in. diameter was annealed by being heated to redness in a forge fire, and there allowed to remain until the fire died out, and the rod became comparatively cold; it was then supported horizontally on glass, and placed due north and south in such a position as to be in a direct line with the lowest magnet. Then by moving the astatic arrangement into different positions while the rod remained stationary, the directions assumed by the magnets indicated the direction of the magnetic lines of force emanating from the iron rod. In experiments with this kind of measuring instrument great care must be taken not to place the magnets too far from the iron, because the low intensity of the magnetism induced in the iron by the earth's polarised lines of force is then insufficient to fully overcome the very slight torsion of the silk fibre, or the absence of absolute uniformity of magnetic tension in the small magnets. On the other hand, if the magnets be placed too close to the iron, it will be found that they induce magnetism into the iron, and, consequently, interfere with the results. It will therefore be understood why very careful adjustments are necessary before reliable data can be obtained.

(To be continued.)

THE ANGLO-AMERICAN TELEGRAPH COMPANY.

A meeting of shareholders in this Company, convened by the provisional committee of the shareholders' association, was held on the 5th inst. at the Cannon-street Hotel.

On the motion of Mr. John Newton, seconded by Mr. Griffith, Mr. Thomas Smith, of York, was voted to the chair.

The Chairman said he supposed they had all received a circular from Mr. Stockdale and himself. He might at once tell the shareholders that the committee were self-elected, but they thought that before the next general meeting of the shareholders took place, they should themselves elect from their own body a committee to represent them. As they were aware, at the usual meetings of the Company any single person who proposed any resolution was merely pooh-poohed. Where, however, there was unity, there was strength. He did not know whether or not the committee had done any good service, but after working for twelve months he might say that, under the pressure they had brought to bear on the Directors, the latter, although they had said, like the fickle lady, they would ne'er consent, had consented to reduce the amount they had hitherto added to the renewal fund by £50,000. At the end of the half year that fund would amount, if the directors carried out their present proposal, to about £850,000. They considered that it was absolutely necessary that the shareholders should now take some steps to prevent any further addition to that sum, with the exception of the increase which might be made by the accruing interest. As many of them were aware, there was quite sufficient to pay for two cables, which could be laid in 12 months. If anything should happen to the cables, their proportion of the receipts was not stopped for a year, and any men of business, he had no doubt, would lay a cable if necessary within that time. This association was formed last February after the meeting. Perhaps they were aware that he brought forward a motion at the last meeting to the effect that no further addition to the so-called renewal fund should be made with the exception of the accruing interest. The fund then stood at about £750,000. If the idea he then suggested had been carried out there would have been a renewal fund of that amount, and they would have been able to pay something like 3½ or 4 per cent.; but Lord Monck did not think that that was a proper thing to do, and carried out his original idea of adding £150,000 to the renewal fund, though his lordship had since modified that view, and added only £100,000. After the meeting in February Mr. Stockdale called upon him and asked him if he would join an association, and he consented. Mr. Stockdale, Mr. Jackson, Mr. Brown, and himself formed an association themselves, and they had addressed the whole of the shareholders of the Company—no small matter, as they would understand when he told them that there were between 5,000 and 6,000 shareholders. They had addressed the shareholders three times, and he was very glad to say that they had had some very agreeable responses and encouraging remarks from a great many of the shareholders, telling them how glad the writers were that the committee were taking up the question, and hoping that they would pursue the matter to the end. They had now come to a period when they thought they should ask the shareholders to help them and form a committee from among themselves. Any gentleman holding £5,000 stock of any kind would be eligible to act on the committee. He then detailed the amount of work done by the committee, and the expenses which had been incurred. The expense of copying the register was £2. 9s., but it was done by the voluntary labour of Mr. Brown, Mr. Jackson, and Mr. Stockdale. Altogether the amount expended had been £34. 18s. 8d., and they had received £20. 12s. 6d. There was therefore a balance due to Mr. Stockdale of £14. 6s. 2d. In order to provide the necessary expenses which would be incurred, they thought there ought to be a *pro rata* contribution of 1s. per cent. levied on the holdings of the members of the association, with the reservation that the minimum contribution should be 5s. and the maximum £5. They had only that morning received a very encouraging letter from a gentleman at Bury in support of the views of the committee, and urging them to push their association to the front, and "go in for a thorough reconstruction of the Company." The motion he would now propose would be to the effect that the meeting should assist the committee in the election of a committee, the present committee being only provisional.

Mr. Jackson, in seconding the motion, said that the provisional committee represented, with the support they had already received from shareholders, about £1,000,000 of the stock of the Company. The result of their action was already known to the shareholders in a dividend, though a very small one; but the dividend would have disappeared altogether had not the Directors been called to account. He said "called to account" because, as was stated at the last general meeting by a gentleman of some erudition in the law, the Articles of Association were so drawn up that they appeared to have been drawn up for the protection of the Board of Directors. That, however, was accounted for by the fact known to the original shareholders—that the Company was originally a company of capitalists, who subscribed among themselves £600,000 to a desperate concern, when the two first cables were abandoned. The 1865 cable was broken, and the 1858 cable was entirely lost. The case was desperate. There was a sort of national aspiration that there should be

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an Atlantic cable, and certain great capitalists in London met, and in two hours raised the sum he had named. They took care in the Articles of Association first of all to protect themselves; but perhaps the shareholders were not aware that those articles constituted the Articles of Association of the present Company—not representing the capitalists who had subscribed the money, and were bound to secure their own interests, but a Board of Directors who represented a very small amount of capital indeed. In fact, the four shareholders forming the provisional committee held a much larger amount than the whole of the Board; and the number of the shareholders had grown from a few gentlemen to some 5,500 members. Yet the same Articles of Association stood against the shareholders, and gave the Board of Directors an autocracy, an almost irresponsible power; and he felt that this fact only required to be pointed out, when such a state of things would not last. The shareholders were co-partners in the concern, and if they did not look after their own business, but left everything to their servants (and the Directors had themselves stated that they were the servants of the shareholders), they would deserve to go without their dividends. The original founders of the Company obtained 25 per cent. per annum for the loan of their money, for they would not become a cable company at the first. Their contract was 25 per cent. interest, and 100 per cent. redemption money, and they handed their undertaking over to the original Company. Those gentlemen had received a very excellent return on their investment. The position, however, was now altogether altered. He mentioned these facts to show that it was necessary on the part of the shareholders themselves to wake up to a sense of their true position. The Company was now in such a position that whatever circumstances might arise, beyond putting competition aside, there did not seem any need for anything like the huge amount forming the renewal fund. In 1872, when the 1865 and 1866 cables constituted their property, and there was a prospect of their being lost—and they were lost and abandoned—they did not put more than £65,000 a year to the renewal fund. Now, however, they had a fund representing at least two deep sea cables, and with the interest of £30,000 a year which the investment forming that fund earned, it would soon amount to £1,000,000. Mr. Cyrus Field, too, had given them the most satisfactory assurances as to their position, and he did not suppose there was a better judge living as to the value of their property. Under these circumstances, with four good cables—so good that while all the new cables which pooled with them were broken, the Anglo-American Company's cables for months carried the whole of the Atlantic traffic—there was ample evidence that they did not require any more renewal fund. The simple issue was to stop the drain on their resources which the renewal fund had hitherto caused, letting it now for the future accumulate by the interest it earned, and to give the shareholders the net earnings, to which they were entitled. If the shareholders approved of those views let them support the provisional committee, who desired to serve the general body of the shareholders—preferred, ordinary, and deferred—who would insist on justice being done. They would succeed if only the shareholders supported them by purse and person, though the cost would not be very much.

Mr. PRUST said he desired to thank the committee warmly for what they had done, but he could not agree entirely with their views. He had sustained a serious loss in the Company, but seeing they had a renewal fund of £800,000, he thought, as he said at the last meeting, that it should be allowed to mount up to a round sum of £1,000,000. No speculators could take it away from them, and they would place themselves in a better position. In saying that he would add that for four years he had received no interest on the deferred shares he held, for which he gave 36, while that day they were only 10. The renewal fund had been formed entirely by money which would have gone to the deferred and the ordinary stockholders had it been distributed; and supposing that the company were liquidated now, the money at the credit of the renewal fund would return to those from whom it had been kept. Much as he appreciated what the committee had done, he therefore held that the best course was to let the renewal fund go on increasing to £1,000,000, especially as it was to be remembered that he got a motion carried at the last meeting, and agreed to by the Directors, that they would never use 6d. of that fund for a new cable without the sanction of a meeting of the shareholders [no, no]. There were eight cables in the pool, but with the contraction of commerce between this country and America, they had not been doing much business, and there was no necessity for another cable. He was prepared to support an alteration of the Articles of Association; and the way in which the Directors acted in issuing proxies, and so spending hundreds of pounds in their own interest, and against the shareholders, in order that they might be able to stand a consolidated force opposing the shareholders at the meetings, was much to be condemned. He trusted that some eminent lawyer or other gentleman who had been returned to Parliament would bring this matter before the Legislature, and expose the iniquitous course pursued by Directors in connection with the proxy system.

Mr. GARDNER asked whether the Articles of Association of the Company could be altered so as to authorise the purchase of their own stock, and so reduce the capital. If so, it seemed to him that that would satisfy all classes of shareholders.

The CHAIRMAN: It would require an Act of Parliament to do that.

Mr. JOHN NEWTON stated that, having been a shareholder for many years, he had seen the gross iniquity of the Articles of Association, and suggested their remedy years ago. He thought it would be a great service to the Company and all telegraph companies if they directed their attention to altering the Articles of Association and dealing with the question of the proxies. He suggested that the report of the Directors should be met with an amendment opposing the item of expense on the proxies. They could not do more until the Articles of Association were altered. It should be their policy to get an adverse division against the Directors at every meeting, and he did not think they could continue indefinitely to hold their positions if that course were followed. They could not move a resolution on any business at the general meetings unless notice had been given to the Directors and the notice had appeared in the official advertisement calling the meeting; but the Directors could checkmate the shareholders by excluding from the advertisement the very notice which the shareholder had sent them. The proper course, therefore, was to get the holders of £50,000 or £60,000 of the stock to ask for a special meeting. That was what the very same body of gentlemen had told him in the Eastern Telegraph Company. Some of them might remember that he drew attention to the Articles of Association as to the election of Directors; and if they read those articles they would find that it was utterly impossible for the shareholders to elect a Director; for this reason, that the gentleman who proposed to be elected must himself give notice some three months before the meeting, and state that he was going to put himself forward for the position. But what respectable man in the City of London would put himself forward to oppose a gentleman against whom personally he had no feeling? Practically the Articles of Association asserted that the shareholders had not one iota of power. The proxies presented for the last meeting at the office of the Company more than 48 hours before the time appointed for the meeting were refused, on the ground that according to the Articles of Association they should have been deposited 48 hours before the day of the meeting. Everyone, however, knew that if proxies were handed in 48 hours before the meeting, that would be sufficient; but in the case of this Company the articles were against it. It was simply "crying over spilt milk" to protest against the articles as they stood — they must be altered. He thought the policy of the committee should be to submit an amendment to the report of the Directors, against the expenditure for proxies and any objectionable paragraph in the report, but the amendment must be so couched as not to enable it to be said by the Chairman that it was "a negative." Some of them might remember that he proposed a resolution at one of the meetings opposing the election of Lord Montagu Hay. For that resolution two hundred hands were held up, while there were only ten against it. Lord Monck, however, on that occasion said he would use the proxies, but the meeting rose with indignation against such an idea. His lordship then asked to be allowed to retire to another room to consult with the Directors, and when they came back they said the proxies would not be used, but the voting would be kept open until five o'clock. He (the speaker) knew as a fact that they then sent a message to members of the Stock Exchange to tell their friends it was necessary to go to the meeting of the Company and vote. They did so, and the resolution he had brought forward was defeated in that way. He thought that the Directors of the Company were excellent business men; but they were vastly over-paid. If they made a calculation of how much the directors of telegraph property had received it was scandalous. [A Voice: "With nothing to do."] There was, no doubt, plenty to do. Was it not, however, a gross injustice that the salaries of the Directors should be so enormous when those of them who were in business must know that their profits from that business had been reduced by 50, 60, 70, or 80 per cent.? Their remuneration as Directors had not been reduced, notwithstanding the fact that those for whom they worked, the shareholders, had suffered considerably in having reduced dividends, there ought to be some connection between the prosperity of the shareholders or their adversity and the prosperity and adversity of Directors. He had himself supported an addition to the fees of the Eastern Company's Directors; but he did not mind paying Directors well when the shareholders were prosperous, though he held that they should suffer when their shareholders suffered.

Mr. DAVISON said that from the remarks of the previous speakers and his own careful observation, he gathered that there were really two questions which demanded the serious consideration of the shareholders—one was the Articles of Association, which were quite inadequate to the requirements of the Company as at present constituted, and the other was the magnitude of the renewal fund. The articles required alteration, and the proper way to accomplish that was to have an extraordinary general meeting of the Company called for that special purpose. From every quarter he heard that an alteration ought to be made; but he had never heard it discussed how it should be accomplished. He thought the power should be delegated to a committee of the shareholders, who would go into the question carefully, and make alterations in accordance with the requirements of the present time. As to the renewal fund, there could not, he maintained, be a shadow of doubt that that sum was really larger than was required. Having had some little experience in these matters, he had long ago arrived at the conclusion that the 10 per cent., or £700,000, would be a very proper provision for the Company to lay aside for such contingencies as such a fund was called upon to meet. Were the fund below that amount he would be one of the strongest advocates to bring it up to that, but it was now over £800,000, and they did not know that it was not intended to go beyond £1,000,000. Measures ought to be taken to prevent it from getting any larger, especially when it was apparent that the great body of shareholders were anxious that that should be done, so that the deferred shareholders might have some little justice meted out to them. As the Directors had shown a disposition at the last few meetings to carry their point against the express wishes of the shareholders he thought it behoved them to form a committee for the purpose of checking the tendency to further increase the renewal fund. He supported the views which had been enunciated by the Chairman and Mr. Jackson.

The CHAIRMAN said he thought Mr. Prust was labouring under a little mistake. Mr. Prust had stated that the fund of £850,000 was now under the protection of the shareholders, and that at his suggestion the Directors had agreed that the fund should not be used without the sanction of a meeting of the shareholders. The Directors took quite a reverse decision.

Mr. PRUST said he thought his motion was agreed to.

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Mr. JACKSON: Oh, no. If Mr. Prust referred to the report of the meeting he would find that Mr. Chester's resolution—which he believed was Mr. Prust's originally—was out-voted enormously by the proxies.

Mr. NEWTON said that that was so.

The CHAIRMAN added that the Directors went to the poll, but they (the opposing shareholders) did not. Mr. Chester's proposal was, "That no contract for the laying of any new cable be entered into by the Board of Directors without first obtaining the consent of the shareholders in public meeting." That was discussed, and lost in the manner stated.

Mr. DAVISON: It was out-voted?

Mr. JACKSON: Enormously.

Mr. PRUST: Not by the shareholders present, but by the proxies.

The CHAIRMAN: Yes, that is so; but the matter is entirely in the Directors' hands.

Mr. DAVISON said he could not agree that proxies should be abolished. As a rule, the shareholders at a meeting represented one-tenth of the entire number, and he thought it would be rather an error to hold that the other nine-tenths should not record their opinions. He was aware that proxies were improperly used occasionally, and even the resolution just read rather showed that, but he did not think that that fact formed a reason for their condemning proxies altogether.

Mr. GRIFFITH agreed with what had been said, that the shareholders should feel indebted for the labour which had been undertaken by the provisional committee in the interests of the shareholders. When they considered that the cables in existence were more than sufficient to do double the amount of business which they now had to do, the time had come when their large insurance fund need not be increased. An additional argument in favour of that view was that there were other cables besides their own, that they were able to carry the messages, and that even were the Company's cables to break, their earnings would be the same for 12 months. As to the question of proxies, it might not be wise to allow directors to issue proxies, but if they did he thought they should pay for them themselves. Though he would not exclude absent members of the Company from expressing their opinions, he would not allow the Company to be mulcted of a large sum in paying for the dilatory conduct of those who did not come to the meetings. The shareholders were not satisfied with having their funds wasted, their votes ignored, and with being played with time after time by the Directors. It was the shareholders who represented the Company, though it was true that the Directors were the managing partners. The Directors, however, did not represent the views raised at each annual meeting. He, like the other shareholders, had attended these meetings from time to time, and the expressions of opinion uttered had been strongly condemnatory of the Directors; decided views had been expressed that reform was needed, and that the time had come when that reform should be carried out. The statement was quite correct that those reforms could not be carried out without revising the Articles of Association. Those articles had been drawn in a very unfair way, and had given powers to the managing partners which they ought not to possess. The managing partners were thus able to override the interests and wishes of the shareholders at large. That was never the intention of Parliament. He was looking at the articles a short time since, and there was one merit about them as they were originally—namely, that the reserve fund was not to be used simply as an insurance fund, but for the general benefit of the Company, so that dividends might be equalised, and other contingencies provided for occasionally. The Directors, however, saw that that would diminish their power, and a special meeting was called to alter the articles. Alterations were then made, by which this power had been taken away from the shareholders at their general meetings, and confided to the Directors alone. They were therefore not mere socialist reformers. They simply wanted those rights which they formerly possessed, and they would succeed if they only had the courage to go on. Any articles could be altered by two special meetings called in accordance with the Act, and it was therefore a question whether they who held the views expressed at that meeting would see them carried out or not. They knew from the views expressed at the annual meetings that they had the support of the London shareholders and of those who came up from the country to attend the meetings; and he therefore thought they might look forward with some confidence to the time when they would see their views carried into effect.

In reply to a SHAREHOLDER, who said that his dividend had been reduced without competition existing,

Mr. GRIFFITH stated that on one occasion the Directors anticipated competition, and lowered the rate per word long before the competition.

Mr. PRUST: And lost £70,000 by doing so.

Mr. DAVISON stated that he had not been aware of what Mr. Griffith had stated—that the Articles of Association had originally been drawn up in favour of the shareholders, and had been altered.

Mr. STOCKDALE replied that Article 28 had been altered by special resolution of an extraordinary general meeting of the shareholders.

Mr. DAVISON: The very thing we wish now to restore.

Mr. STOCKDALE: Exactly. It was done by the proxies.

The CHAIRMAN stated that the committee had heard the remarks which had been made, and quite agreed with them, but before any further steps could be taken they must appoint a committee. Probably those who had heard the remarks which had been made would then see if they could carry them out.

Mr. PRUST was asked to be a member of the committee, but stated that he was so situated that he could not accept the invitation.

On the motion of Mr. STUBBINGS, seconded by Mr. PRUST, Mr. Davison was elected a member of the committee.

The CHAIRMAN said they wanted a committee of seven.

Mr. PRUST inquired whether Mr. Griffith would give the shareholders his assistance as a member?

Mr. GRIFFITH replied that he would be very glad to do so.

Mr. DAVISON thought that the qualification named of £5,000 might debar some gentlemen from joining the committee. He did not say that on his own behalf, as, unfortunately, he held more than that amount.

Mr. STOCKDALE stated that their object in naming that amount in the first instance was that the committee were a self-elected body, and that unless each member had a considerable holding in the stock of the Company the shareholders might get an impression that they had other motives than the general welfare of the whole body.

Mr. DAVISON: What is the qualification of a Director?

Mr. STOCKDALE: £500.

Mr. DAVISON said he thought that if a shareholder held £3,000 that would be quite sufficient.

Mr. JACKSON replied that probably there would be no objection to a gentleman if he had £3,000. Or the shareholders might say that if the effort now to get seven members was not successful, those who formed the committee should have power to add to their number.

Mr. NEWTON said he thought that if two gentlemen were appointed from the meeting, and there was power given to elect the others, it would be all that was necessary.

Mr. GRIFFITH said he thought that the committee would approach the Directors with quite sufficient weight.

The CHAIRMAN stated that the four members of the provisional committee held among them £80,000.

Messrs. Davison and Griffith were then severally appointed members of the committee.

On the motion of Mr. DAVISON, seconded by Mr. PRUST, the members of the provisional committee were elected members of the committee now appointed.

In reply to the Chairman,

Mr. NEWTON said he would rather not be on the committee, but would gladly give any assistance he could.

A vote of thanks to the Chairman closed the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Jan. 6.		Business Done Week Ending Jan. 6. Highest.	Lowest.
Anglo-American	31,	32	31¾	31⅛
Do. Preferred	53,	54	54	52½
Do. Deferred	9½,	10½	10¾	9⅝
Brazilian Submarine	10⅝,	10⅞	10¾	— x.d.
Cuba	10½,	11	10⅞	10⅝
Do. Preference	17½,	18½	18	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9⅜,	9⅝	9⅞	9
Eastern Telegraph	11¾,	12	12	11⅞
Do. 6 per Cent. Preference	13½,	14	14	13½
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	12¾,	13	13	12 13-16
German Union	9½,	10	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7⅛	7
Do. Preference	18½,	13¾	13¾	13½
Great Northern	14¼,	14¾	14¾	14¼
Indo-European	82½,	83½	—	—
Reuter's	7,	7½	—	—
Submarine	200,	210	206½	204¾
Wes, India and Panama	⅝,	⅞	—	—
Do. 1st Preference	8¼,	8¾	8½	8⅜
Western Brazilian	6¾,	7	7	6⅝
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telepho e and Maintenance	15-16,	1 1-16	1	—
Oriental	3-16,	5-16	¼	—
United Telephone	12½,	13	13½	12 9-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3¾,	4	4¼	3⅞
Do (fully paid)	5½,	6	6⅛	5⅞
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1½,	1¾	2⅛	1⅛
Maxim-Weston	⅜,	½	7-16	—

MISCELLANEOUS.

Telegraph Construction	36½	37½	37	36¼
India Rubber, Gutta Percha, and Telegraph Works	24½,	25½	25¼	25 1-16

TRAFFIC RECEIPTS FOR DECEMBER, 1885.

Companies.	Dec., 1885.	Dec., 1884.	Increase.	Decrease.
Cuba Submarine	2,450	2,553	—	103
Direct Spanish Telegraph	1,754	1,748	6	—
Eastern Extension	34,785	41,426	—	6,641
Eastern Telegraph	53,179	53,086	148	—
Great Northern	20,280	—	—	—
West Coast of America	—	—	—	—

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NOTES.

NOTICE OF REPAIR.—The cable between Trinidad and Demerara is repaired.

TOWN LIGHTING.—It is stated from La Creuse, that the town of Bourganeuf (3,700 inhabitants) is about to be lighted by electricity.

H.M.S. "INFLEXIBLE."—This vessel is to be fitted with electric indicators on the plan designed by Lieut. Lloyd, of the "Excellent."

THE PARISIAN OPERA HOUSE.—The installation at the Opera is now complete, and about 1,684 Edison lamps do nightly duty.

AUSTRALIA.—The Government of Western Australia has invited tenders for the construction of about 900 miles of telegraph wire.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 8th inst. amounted to £3,091.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—The gross earnings of this company for the month ended 31st December, 1885, were £3,825.

THE TASMANIAN DUPLICATE CABLE.—A telegram from Flinders states that the duplicate cable between Victoria and Tasmania was being laid successfully.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—It is notified that the directors of this company declared, on the 13th inst., a dividend for the past half-year of 3s. per share.

FOR WORKS.—The artillery workshops of Saint Thomas d'Aquin, Paris, are about to be lighted by electricity. Gramme regulators will be used, and incandescent lamps of 12 candle-power.

AN INTERESTING CONFERENCE.—An interesting conference took place a few days ago in the municipal offices of the 4th Arrondissement at Paris upon the electric lighting of the Tour St. Jacques.

LIGHTING OF A TRANSATLANTIC LINER.—The new transatlantic liner, the "Gascoyne," which has just been launched at La Seyne, near Toulon, will be lighted throughout by electricity.

THE TELEPHONE IN ITALY.—The telephone is likely to go ahead in Italy. Special laws are being framed with a view to promote the industry, and concessions for fifteen years are to be given to eligible persons.

THE VAN RYSSELBERGHE SYSTEM IN AMERICA.—By means of the Van Rysselberghe system articulate speech has been successfully transmitted between New York and Chicago, a distance of about 990 miles.

COMMUNICATION BY SUBMARINE CABLES.—Recent issues of our Italian contemporaries *Fanfulla* and *La Tribuna* contain an account of an interesting conference, initiated by Cav. Salvatore Raineri, upon "Telegraphic Communication by Means of Submarine Cables."

THE HAMMOND COMPANY.—Mr. William Theobald, liquidator of the Hammond Electric Light and Power Supply Company, has given notice that he is prepared to pay the debenture holders upon application.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 8th inst. were £2,336, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE AURORA BOREALIS.—A magnificent display of Aurora Borealis was witnessed on Saturday evening from places in Forfarshire and Kincardineshire. It is said that during its continuance the electric bells in many railway signalling cabins were rendered useless.

THE TELEPHONE IN AUSTRIA.—The use of the telephone is fast extending in Austria. Communication has just been established between the town of Gleichenberg, one of the principal industrial centres of Bohemia, and Gablonz, another manufacturing town twelve miles distant.

THE INTERNATIONAL ELECTRIC COMPANY.—At a general meeting of this company, held on Wednesday the 13th inst., resolutions for the voluntary winding-up of the company were confirmed, and Mr. Ernest Cooper, of the firm of Cooper Brothers and Co., was appointed liquidator.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The Directors of this Company, in their annual report, state that, after providing for the dividend of 2¾ per cent. already announced, and supplementing the renewal fund by £10,000, the sum of £3,459 will remain to be carried forward.

THE ELECTRIC LIGHT AT WILLIS'S ROOMS.—On the occasion of the exhibition of pictures of the Alpine Club, three of these rooms were lit up by forty 20 candle-power Woodhouse and Rawson incandescent lamps, suspended from the ceiling. The work was done in accordance with the rules of the Phœnix Fire Insurance Office.

GERMAN UNION TELEGRAPH COMPANY.—This company is paying, as from the 8th January, the dividends for the past financial year on the Five-and-a-Half per Cent. Original Preference shares, as also an interim dividend of 4 per cent. upon the dividend due in respect of the Original stock on the 1st of May of this year.

STRUCK BY LIGHTNING.—Two labourers, father and son, named Tench, were killed by lightning on 25th November near Ballarat, in Australia. They were engaged in splitting in the neighbourhood of the Gong Gong Reservoir, and while sheltering themselves under a tree from a thunderstorm they were struck dead by lightning.

HONOURS.—We are glad to learn that M. Gaston Planté has been nominated Officer of the Legion of Honour. The same distinction has also been conferred upon M. Clémandot and M. Jules Duboscq, while M. Ducretet has been named Chevalier of the same order. M. Renard and M. Krebs are nominated Officiers d'Académie.

WINTER THUNDERSTORM.—The destructive hurricane which swept over the midland and western counties on Wednesday morning was attended in the neighbourhood of Aylesbury by a terrific thunderstorm. The roof of a farmhouse at Weedon-hill, near that place, was struck by lightning and greatly damaged, as was an adjoining wall.

THE DIRECT UNITED STATES CABLE COMPANY.—We are informed that the Board of Directors of this company resolved on the 8th inst. upon the payment of an interim dividend of 3s. per share, being at the rate of three per cent. per annum for the quarter ended 31st December, 1885, such dividend to be payable on and after the 23rd inst.

RE-OPENING OF A TELEGRAPH SCHOOL IN BOGOTA.—It has been decided to re-open the Telegraph School in Bogota, U.S. of Colombia, which, owing to the late war, has been closed for over a year, and to add to it a special department

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for women. The Inspector-General of Telegraphs, Mr. Ernest Danvers, has been appointed the Director-in-Chief.

THE INVENTIONS EXHIBITION.—In explanation of the large difference there will be when the accounts are made up between the profits of last year's Exhibition and those of the "Fisheries," the *Daily Telegraph* states, among other causes, that the electric lighting, which cost the "Inventions" a large sum, was almost entirely a gratuitous outlay by exhibitors in 1883. We altogether doubt this statement.

EARTHQUAKE SHOCKS IN ROUMELIA.—A Reuter's telegram, dated Philippopolis, Jan. 9, states:—"A slight shock of earthquake occurred here at eight o'clock yesterday evening, and was followed at five minutes to four this morning by several shocks of a more violent character, the vibrations lasting nearly five seconds. The movement was in a south south-easterly direction."

THE OXFORD LOCAL BOARD AND UNDERGROUND WIRES.—At the last monthly meeting of this board the recommendation of the General Purposes Committee that application be made to the Postmaster, asking him to remove the nine telegraph poles north of St. Margaret's-road, and to substitute underground wires, was adopted.

CENTRAL STATIONS IN FRANCE.—The central lighting station on the Edison system at St. Etienne is making a great success. More than 2,000 lamps are in operation, and it has already been found necessary to increase the number of dynamos. The station at Dijon is also work ing up to its full capacity. A third circuit has been added, and the number of lamps increased from 375 to 500.

PRIVATE BILLS IN PARLIAMENT.—Saturday was the latest time allowed by the regulations of Parliament for the deposit of petitions alleging non-compliance with the Standing Orders in respect of the first 100 Bills in the general list. The following is among the petitions lodged, with the titles of the Bills in regard to which non-compliance is alleged:—West London Electric Lighting Company.

THE INDIAN TELEGRAPHS.—The largest contract for iron-work in connection with telegraph work in Staffordshire has just been placed by the Indian Telegraph Department with Messrs. Bayliss, Jones, and Bayliss, for telegraph poles and accessories. The aggregate value is about £50,000, and to execute the contract in six months special plant is being laid down, and extra hands are being taken on.

THE BAUDOT TELEGRAPH SYSTEM.—The rotatory speed of the Baudot distributors varies between 155 and 180 revolutions per minute. On certain lines a speed of 210 revolutions is obtained. Taking 165 as a mean, the single instrument can transmit 165 letters, or 25 words, per minute, or 1,500 words per hour. The sextuple instrument transmits 900, or a total of 400 to 450 messages of 20 words per hour.

BOOKS RECEIVED.—"Magnetism and Electricity for the Use of Students in Schools and Science Classes," by H. C. Tarn, M.C.P., F.S.Sc. (London and Edinburgh: W. and R. Chambers). This is a little work in which an earnest attempt has been made to provide the student with all the knowledge necessary to enable him to make sure of a first class in the elementary examination of the Science and Art Department.

BURMAH.—The following telegram has been received at the War Office from General Prendergast, dated Bhamo, Dec. 29, 1885:—"The water is so shallow that steamers cannot approach nearer than two miles from Bhamo. Telegraph line in disrepair all the way up. Have arranged for its re-establishment from Mandalay to Tsengoo, and will continue the line to Bhamo when operators and instruments have been received."

THE BURTON TOWN COUNCIL AND THE TELEPHONE.—At the last monthly meeting of this Council it was suggested that the utility of the suburban fire stations should be increased by telephonic communication between them and the borough brigade station. The Fire Brigade Committee, at all events, might consider whether the advantage would justify the cost which would be incurred. It was promised that the suggestion should be considered.

THE MANCHESTER ART GALLERY.—At the last monthly meeting of the Manchester City Council, Mr. Alderman Hopkinson, in moving the adoption of the proceedings of the Art Gallery Committee, said the autumn exhibition was now closed. The exhibition had been more successful than any that had preceded it in all respects. The electric light had been an immense comfort and advantage, although it was not altogether perfect yet.

TOYNBEE HALL.—We have received the syllabus for the ensuing term, relating to the Whitechapel Centre of the London Society for the Extension of University Teaching, at Toynbee Hall, 28, Commercial street. The list of lectures includes a course of ten by Dr. J. W. Waghorn on "Voltaic Electricity," with experiments, which commenced on the 12th inst., and will be continued every following Tuesday during the term, at 8 p.m. The charge for each course of lectures at this Institute is only one shilling.

JAPAN.—S. Tegima, Minister of Education, Tokio, Japan, has obtained leave to have translated into Japanese Prof. Guthrie's syllabus of instruction in elementary practical physics as pursued at the Physical Laboratory of the Normal School of Science and Royal School of Mines, South Kensington. The Japanese Government propose to introduce this system of practical instruction into the elementary schools as well as into the normal schools of Japan. Prof. Guthrie has promised to write a preface to the translation.

THE PATENT LAWS.—A preliminary meeting of the Committee appointed to inquire into the administration of the Patent Laws was held on Wednesday. There were present Baron Henry de Worms, M.P. (who was appointed chairman), the Earl of Crawford and Balcarres, and Sir Farrer Herschell. Arrangements were made relative to the subsequent sittings of the committee, by whom a thorough investigation is to be made not only into the application of the laws bearing on patents, but into the organisation of the Patent Office.

SAD DEATH OF A TELEGRAPHIST.—On Saturday afternoon a youth named Frank Helliwell, junior clerk in the telegraph department of the Sheffield Post Office, lost his life while skating on Low Forge Dam, Wadsley Bridge, near Sheffield. About fifty persons were skating there, when the ice gave way beneath two men named Arthur Roberts and Richard Atkinson, and deceased, who was close behind them, followed them into the water. Roberts, who could swim, managed, with the assistance of the spectators, to save himself and Atkinson, but Helliwell was drowned. His mother, a widow, is postmistress at Hellsborough, a Sheffield suburb.

THE VIOLENT STORM IN THE MIDLANDS.—During the violent storm which swept over the Midlands on Wednesday last, a terrific gust of wind carried away the roof of the Great Western Railway Station at Stratford-on-Avon, a large structure 150ft. in length. Fortunately, at the time of the occurence, no train was in the station, nor was one expected, so that the platforms were deserted by passengers, otherwise a terrible calamity must have been the result. The telegraph

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posts were blown down or broken by the falling *débris*, and the wires lay upon the ground. This completely cut off all telegraphic communication with the town, and totally disorganised the work of the post office.

KING'S COLLEGE OLD STUDENTS' DINNER.—The annual dinner of the old students of King's College was held in the great hall of the college on Tuesday evening. The Rev. Canon Ince, D.D., Regius Professor of Divinity, Oxford, presided, and among those present were the Rev. Prebendary Wace (principal of the college), General Sir Richard Wilbraham, K.C.B.; Mr. J. Shires Will, Q.C., M.P.; Mr. T. Eccleston Gibb, M.P.; Dr. Hopkinson, F.R.S.; Mr. W. H. Preece, F.R.S.; Prof. Stanley Leathes, Prof. Robinson, Prof. Seeley, Prof. Adams, Prof. Shelley, Prof. Warr, Prof. Douglas, Prof. Curnow, Prof. Cutter, the Rev. Henry White, Mr. John Hernaman, Mr. A. H. Crockford, and Mr. W. E. Limes.

EARTH CURRENTS.—A very interesting letter has reached us relative to the occurrence of exceptionally strong earth currents on the cables of the Eastern Telegraph Company on Saturday, the 9th inst. From Singapore very strong currents are reported on the China coast, Philippines, and Cochin China cables from about 3 to 5 p.m., and on the Java and Australia cables from 4 p.m. until late in the night, Singapore time. At Corfu the earth currents were noticeable all day on the Trieste cable, but were most powerful between 7 and 11 p.m., and at Gibraltar very strong currents were observed on the Malta, Lisbon, and Villa Reale cable. On the following day the phenomenon was also apparent, but was not so marked as on Saturday.

THE ELECTRIC LIGHT IN BRUSSELS.—The *Chronique des Travaux Publics* announces that it is proposed to electrically light the district of Brussels comprised between the Rues de l'Ecuyer, d'Arenberg, from La Montagne and the Marché-Aux-Herbes on one side, and the Rues des Bouchers and des Dominicians on the other side. This proposal is received with considerable interest, in that the quarter mentioned contains the galleries Saint-Hubert, with the two theatres, l'Alcazar, and a number of large cafés and public buildings, in which the electric light might advantageously be employed. The new theatre of the Bourse, which was opened on the 30th of last month, has only received a small installation, consisting of six lamps, supplied by 360 Bunsen batteries of 60 cells.

THE BELL TELEPHONE CASE.—Associated Press reports in America state that the Interior Department has decided to recommend that the Attorney-General authorise suit to be brought in the name of the United States to test the validity of Bell's original patent. Although the full text of the decision will not appear for some days, it is said that it will set forth, among other things, that "the specification of Bell's patent contains nothing about the capability of Bell's instrument to transmit articulate speech, but only claims for it the power to transmit 'vocal sounds;' that an instrument may transmit 'vocal sounds' without being a speaking telephone; and that, in point of fact, Bell did not invent a speaking telephone until after the issue of his patent, as appears from the record."

THE TELEPHONE LINES AND THE LATE SNOW STORM.—The National Telephone Company writes to inform us that during the late snow storms, although they have different gauges of wire, such as iron, copper, and bronze, on the same poles, there was not a single break-down recorded, although one of the junction poles, 105ft. high, carries 190 wires, consisting of No. 17 copper, No. 11 covered iron, and 18 G bronze. The trunk lines to Loughborough, Long Eaton, and Ilkeston, and three suburban junction lines also escaped interruption. The first-named trunk loop exceeds 40 miles in length, being connected on the metallic system, and passing through a very wooded district. The following fires were signalled within the borough of Nottingham during the month of December, 1885, viz.:—Two by telephone, and 12 by street fire alarms.

THE GERMAN TELEGRAPHS.—Herr Stephan, the Minister of Posts and Telegraphs for the German Empire, in a report just presented to the Emperor, gives some account of the progress that has been made in internal communications throughout Germany during the last four years. Telegraph stations have in that period been increased by 1,639. They now number 7,535, or one office to every 5,000 inhabitants. No statement of revenue and expenditure is given in this report, consequently we can form no opinion as to the financial results of Herr Stephen's administration; but it is said that the German telegraph system is "not conducted on commercial principles," which we can quite believe seeing that this energetic minister has done his best to compel English cable companies to carry on their business for the benefit of the world at large, and at a loss to themselves.

LIGHTHOUSE ILLUMINANTS.—In a paper recently read before the Edinburgh Royal Society by Mr. J. Stevenson, M.I.C.E., on lighthouse experiments, it was stated that the electric machine proposed to be employed at the Isle of May was a Brush machine, in which the current was continuous. An altogether unlooked for difficulty had been experienced, however, by the agents for this mode of lighting, in constructing a satisfactory lamp; and this difficulty had not yet been wholly overcome. But the light from the alternating current machines of De Méritens had been dipped satisfactorily at the South Foreland, not only by the arrangement which he (the author) suggested, but also by another mode subsequently suggested by his late pupil, Mr. Brebner, jun., so that, by either of these methods, there could be no doubt a light from the electric lamp could be dipped to suit any required conditions.

THE DISTURBANCES IN KHORASSAN.—A telegram dated Teheran, Sunday, says: "News received since yesterday from Meshed shows that telegraphic communication has again been established between that place and Teheran. It is found that the office at Meshed had been seriously damaged and the wire destroyed in three places. Further advices through Reuter's agency and dated Teheran, 10th inst., report that disturbances have broken out at Meshed, in consequence of the Governor of Khorassan again attempting to increase the taxation. Telegraphic communication was unfortunately interrupted in consequence of a heavy fall of snow, and great apprehension was felt here, owing to a rumour that the Governor had been murdered. Telegraphic communication was restored last night, and the central Government immediately telegraphed in reply to the priesthood that the inviolability of the Shrine would be respected."

ELECTRIC LIGHTING CONTRACT.—From the *Contract Journal* we notice that the following tenders have been received at Egremont, Cheshire, for fitting up the electric light on six passenger steamers, for the Wallasey Local Board:—J. J. Marr and Co., 31, Moorfields, Liverpool (accepted); J. D. F. Andrews and Co., Woodside Electric Works, Glasgow; Siemens Brothers and Co., 12, Queen Anne's-gate, Westminster, London; G. Durham, 62, Shaw-heath, Stockport; H. Bury, 27, Arcade-chambers, St. Mary's Gate, Manchester; W. L. Fleming, 15, Stanley-street, Liverpool; the Simplex Electric Light and Plant Company, Valley Mills, Eccles, near Manchester; Laing, Wharton, and Down, 8 and 9, Holborn-viaduct, London, E.C.; Gardners (J. and C.

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Christie), 453 and 454, Strand, London, W.; Bailey and Grundy, Amberley-road, Paddington, London: the Manchester and District Edison Electric Light Company, 19, Victoria-buildings, Manchester.

PERSONAL.—The appointment of Señor Saturnino Islas, of the City of Mexico, to the position of Director-General of all the Government telegraph and telephone lines in the Republic of Mexico appears to have given satisfaction. Señor Islas is well fitted for the high position conferred upon him, having had many years' experience as superintendent of telegraphs for the Mexican Railroad, besides having been prominently identified with the telephone and electric light in the Mexican Republic. The work of reform inaugurated is already spoken of in high terms, and a bright future is apparently before him. He is said to be possessed of great executive ability, and his integrity is known to be irreproachable. It is interesting to know that Señor Islas was trained in the English Railway Company, whose lines connect Vera Cruz with the City of Mexico. He was afterwards telegraph superintendent of that company. He was before that an officer in the Mexican Army (during the French invasion), and distinguished himself.

THE TELEGRAPH SYSTEM IN VICTORIA.—The statistical return of the telegraph system for eleven years ended 1884 shows the following relations:—The number of stations opened in 1874 was 148, and the lines carried 4,293 miles of wire. The number of telegrams sent was 705,108, of which 121,285 were free, the amount received for the messages being £42,825. In 1884 the stations had increased to 404, the miles of wire to 8,055, the number of telegrams to 1,594,296, of which 473,670 were free, and the revenue of £89,077. The greater portion of the materials required for this telegraphic extension were imported from the United Kingdom; for example, the value of the materials exported from the United Kingdom in 1884 was £12,020 out of £15,304, the value of the materials received by Victoria from all quarters. Further, in all probability £245 of this value must also be put to England's account, the materials going through New South Wales instead of direct. Of the rest Antwerp contributed £540, Hamburg £1,037, Marseilles £341, and New York £121.

ELECTRIC LIGHTING OF A CHURCH.—The church of St. George's, Hanover-square, was lighted on the 10th inst. at the afternoon and evening services by the Swan incandescent electric light. Three large electroliers, with some thirty lamps apiece, besides a large number of smaller branches, gave a light which for brilliancy proved far superior even to the broad daylight of this misty mid-winter season. The little lamps glowed throughout the day, and set off the fine interior of the famous church with matchless effect. The experiment is part of a large scheme of domestic lighting originating with Sir Coutts Lindsay's company at the Grosvenor Gallery. At the back of the gallery library a large installation has been started, with machinery of 600 horse-power and two powerful batteries. From this centre wires radiate in various directions, and the electric current is supplied in buildings just like water or coal gas. Already a number of tradesmen avail themselves of the opportunity of using the electric light at their establishments without having the trouble and expense of a separate installation of machinery. The farthest point from New Bond-street at present reached is the Café Royal, near the bottom of Regent-street.

THE COLCHESTER INSTALLATION.—At a recent meeting of consumers of electric light at Colchester, the following resolution was agreed to:—"That in the event of the Electric Light Company being willing to refund 75 per cent. of the amount paid for the installation of the light on their premises, the consumers will offer no opposition to the light being discontinued." The Chairman, in the course of the proceedings, stated that the Company were in treaty for the sale of their plant and works as they stood. A consumer remarked that the Company had promised to give them 20 candle-power; but they had distinctly failed to do so. He was willing to pay for the light they had actually had, but not for the light they ought to have had. It was decided that the liquidator (Mr. Pannell) be requested to make some reduction, in consideration of deficient light, upon all unpaid accounts; taking into consideration that some of the consumers had already received reductions. The resolution was carried. It was understood that the meeting agreed not to offer any opposition to the discontinuance of the electric light; but only on condition that the proposals embodied in both the resolutions were accepted by the company.

ELECTRIC LIGHTING AT LEEDS.—The arrangements for illuminating the Leeds Victoria Hall by electricity are so near completion that two of the arc lamps will be placed in position within a few days, and an experiment will be made in the presence of a number of members of the council. The eight arc lamps ordered have been received, but owing to the fact that the incandescent lamps of Messrs. Crompton remain in the position they were placed in for the last musical festival, the new lamps cannot all be put up yet. The arc lamps now to be introduced are on the Brockie-Pell focussing principle, and will each give a light of 2,000 candle-power. The light will be enclosed in large opal globes, 22in. in diameter, surmounted by an ornamented brass corona, above which is an enclosed cylindrical case about 18in. long, containing the automatic machinery by which the light is regulated. The carbons, which are about 2ft. in length, will burn for 18 hours. The lamps, when fitted, will be worked by 45 batteries, stored in the crypt, and charged as required by the dynamos already existing in the basement of the Municipal Buildings, whence the current will be carried by a subway into the Town Hall, and thence through the false roof into the wires which form part of the ornamental pendants by which the lamps will be suspended from the ceiling of the Victoria Hall.

THE ELECTRIC LIGHT IN HULL.—A very successful installation of the electric light has been put down at the establishment of Messrs. Barnett and Scott, manufacturing art jewellers of Whitefriargate, Hull. The plant is most complete and extensive, and consists of a six horse-power Otto gas engine, which has been laid down by Messrs. Crossley Bros., under the superintendence of Mr. Crabtree, their agent; a Ferranti dynamo and Siemens exciter, the countershafting and pulleys being supplied and fixed by Messrs. Amos and Smith, Hull. The lamps are the Messrs. Woodhouse and Rawson's incandescent of 20 candle-power each, and they are arranged suspended from chandeliers on either side of the extensive shops, six lamps forming a cluster. A sun light of lamps is fixed in the centre of the ceiling, and eight lamps in each compartment of the window. The whole of the lamps in the shop give an illumination equal to 2,000 candle-power, giving a most brilliant effect. The offices and workshop will also be fitted with the same light. A belting fixed to the countershaft of the engine and connecting the lathes and batteries in the manufacturing department will be very beneficial, by giving a speed which cannot be attained by manual labour. The installation has been put down by Mr. Thomas Muse, electrician, Hull.

LIGHTING AT GLASGOW.—The experimental lighting by electricity of the Central Station in Gordon-street, Glasgow,

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has proved so successful that the system is about to receive important additions. The electricity is generated in a large engine room under the station by two Brush machines, each of 25,000 candle-power, while two Gramme machines, each of 4,000 candle-power, are available when required. The Brush machines are, however, sufficient for present purposes at the station, where 48 arc lights are nightly in use, and have never once failed in giving out a brilliant and perfectly steady radiance. Within a few days five or six lights will be added to the existing number. Of these one will be placed outside the covered way at the Gordon-street entrance, showing as far as Buchanan-street and Hope-street, another at the exit in the latter street, and a third will be erected on the parapet of the Argyll-street Bridge. The engines fitted up are powerful enough to supply electricity to the Bridge-street and Eglinton-street stations, to which it will doubtless be applied within a short time. In the Central Station Hotel, it may be added, nearly 200 incandescent lights are in use, supplied by an Edison-Hopkinson dynamo machine. The whole arrangements have been carried out under the superintendence of Mr. A. S. Dunn, the telegraph superintendent for the Caledonian Railway Company.

Electric Lighting at Hatfield House.—On the occasion of the county ball, given by the Marchioness of Salisbury, at Hatfield House, on the 6th inst., the following arrangements were made for the lighting by electricity of the house and grounds :—The principal rooms, galleries, and grand staircase were illuminated by upwards of 900 Swan 20 candle-power lamps, the principal power for these lamps being derived from two waterwheels on the River Lea, which is a mile and a quarter distant from the house. The machinery used for generating the current consisted of two Siemens alternating machines, one 16-light Brush, and one Siemens direct-current machine, the latter being driven by a 16 horse-power Otto gas engine. The terraces and approaches to the house were lighted by six Clark-Bowman arc lamps, the current for these being supplied by an H Gramme machine, driven by a traction engine near the house. The lighting was in every respect a thorough success, and gave great satisfaction, there being not the slightest interruption to the working during a period of sixteen hours. The whole installation was carried out by Mr. Shillito. It may be remembered by our readers that the Marquis of Salisbury has been a pioneer in the matter of electric lighting and the use of electricity, and that his lordship has utilised this agent in a variety of novel ways by the transmission of electrical power, such as for grinding corn at farms situated at some distance from the water-power, pumping water, and driving the ventilating apparatus at the house, driving the lathes and saws in the workshops, pile driving, dredging, and cutting weeds in the river, &c.

The Electric Light at Edinburgh.—The North British Railway Company have just extended the electric light into the booking hall and refreshment and waiting rooms of the Waverley Station, Edinburgh, as well as the entrances, platform, and rooms of the Suburban Railway there. As is well known, the Waverley Station has been illuminated by electric light for some years, and its suitability and cheapness during that time has, it is understood, led to the extension referred to. While the lighting up to the present time has been on the arc system, the new light is on the incandescent principle, and the lamps used in the refreshment rooms are enclosed in dioptric and opaque globes, rather a pleasant effect being produced by the suspension from the ceiling of ornamental lamps by an almost invisible wire. The others are bulb-shaped, about 4in. long, and from 2in. to 1in. diameter, made of clear glass. In the rooms the new light is much superior to gas, but on the Suburban platform, probably owing to the number of lamps being too few, the light cannot be said to be any greater improvement. Altogether about 135 Brush-Victoria lamps have been introduced, each of which is of 20 to 30 candle-power. These are arranged in groups, so that, for instance, one room or entrance may be lighted, while another is not. The present engine will suffice for the additional driving power wanted, though a new Brush-Victoria dynamo, similar to that to be supplied to the Isle of May lighthouse, has been provided. Besides economy in production, it is believed that the electric light will save a repetition of damage to the ornamental ceilings of the refreshment rooms which has been caused by gas during the last few years. The Anglo-American Brush Electric Light Corporation executed the work, under the supervision of Mr. Giepel, their superintendent for Edinburgh, and Mr. Thomas Carsewell, of the engineering department of the North British Railway. The railway company, it is understood, estimate that the lighting of the station will be effected at a cost of about something like half the price of gas.

Electric Tramcars in Berlin.—We have received a further batch of letters and newspapers from our correspondent in Berlin, giving us full accounts of the trials and progress of Reckenzaun's electrically propelled tramcar. From these accounts we learn that its success is quite assured. We are glad of this, but must confess that we regret that an English invention has had to be exported to Berlin in order to find practical development, and we can see in this incident only another sign of the abnormal position into which electrical matters in general have drifted in this country, through causes which have unfortunately not yet disappeared. Mr. Reckenzaun's tramcar—with the principles and construction of which our readers are well acquainted—has now been running daily in Berlin full of passengers, and last week a number of directors of different tramway companies from all parts of Germany inspected the invention. The following is a translation of an article relating to it from the *National Zeitung* of 10th inst. :—"Mr. G. A. Plewe, who represents the invention of the engineer, Mr. Reckenzaun, of London, invited the directors of a number of tramcar companies to the trial, among whom we saw represented the different Berlin companies and those of Spandau, Potsdam, Stettin, Magdeburg, &c., and which constituted a jury of competent and influential men. The car ran from the Exhibition through a number of streets to the Brandenburg Gate, near which place an explanation of the experiment was to be given ; but there was no need to wait for that, because the experience was simply this, that the car ran over one of the worst curved lines of Berlin at the rate of an ordinary tramcar without shaking and without shocks or accidents. It was also evident at once that the car could be stopped in a moment by switching off the current, and that the risk of accident to the car itself or to foot passengers is thus greatly reduced. The electrical details of the system are too well known to need description here. Suffice it to say that passengers were able to see that the boxes containing the accumulated electricity were pushed into the car, that they were placed out of sight underneath the seats, and that the taking out and replacing of the boxes occupied no more time than the changing of horses. The accumulators also supply four 20 candle-power Brush lamps. From the outside the car looks like an ordinary one, only that instead of the driver of horses one can see the engineer attending to the switch, and that instead of running on four wheels the electrical car runs on eight small ones. This last novelty very likely accounts for the ease with which the car turns the curves."

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 148.)

The Mechanical Forces and Stresses. Preliminary. The simple Maxwellian stress.

As this is not a treatise upon the theory of Elasticity, it will be only necessary to say so much on the subject of stresses in general as will serve to introduce us to the principal formulæ connecting stresses with the corresponding mechanical forces, which we may find useful hereafter. This can be done very briefly.

A simple stress is either a tension or a pressure acting in a certain line. It implies the existence of mutual force between contiguous parts of the substance in which it resides, and of a corresponding state of strain, with storage of energy in the potential form, *i.e.*, depending upon configuration, though perhaps ultimately resolvable into kinetic energy. Thus if we fasten a cord to a beam, and hang a weight to its free end, the cord is slightly stretched, the work done by gravity during the stretching is somehow stored in the altered configuration, and the cord is put into a state of tension. At its lower end the tension in the cord is equal to the weight attached, at its upper end to the same plus the weight of the cord. The state of strain of course extends to the beam, and to the beam's attachments, and so round to the earth, to which we ascribe the gravitational force, which is somehow stressed across the air to the weight, and from the weight to the earth.

If the stretched cord be in motion in its own line, as when a horse tugs a barge along a canal, there is, besides the transfer of energy through space by the onward motion of the horse, rope, barge and dragged water, carrying their kinetic energy with them, a transfer of energy through the rope from the horse to the barge, and through the strained barge to the water, where it is wasted in friction. The rate of transfer per second equals the product of the tension of the rope into its speed, and the direction of transfer is against the direction of motion.

If motion be transmitted from one machine to another by means of a horizontal endless band, the transfer of energy is through the stretched half of the band, and is again proportional to its speed (and against its motion), and to the difference of tensions of the two sections; a uniform tension meaning continuously stored potential energy.

A pressure is a negative tension. If the tension or pressure in a cord or rod be not uniform in amount across every section, we see at once that any small piece of the cord is pulled in opposite directions by forces of different amounts. Their difference is the mechanical force on the small piece considered, and measures its rate of acceleration of momentum. Thus, if P be the tension across a section at distance x from one end, dP/dx is the mechanical force at that place, per unit length of cord, acting in the direction of x positive. Unless otherwise balanced, it increases the momentum of the cord. Thus $-dP/dx$ is the force that must be applied to keep the differential stress from working. Examples: (1) A vertically hanging cord; unequal tension; applied force gravity. (2) In the endless horizontal band moving with uniform speed, there is no force resulting from its tension except where it changes in intensity, for example where it passes over pulleys. At a pulley where the band gives out energy, the force and velocity product is positive, and where it receives energy, negative. These forces of the stress variation are the negatives of the forces the pulleys exert on the band.

The most general stress considered in the common theory of elasticity consists of three simple stresses (pressures or tensions) acting in three lines at right angles to one another in a substance. Let them be P_1, P_2, P_3 per unit area, parallel to the axes of x, y, z respectively. These are the stress intensities, the former tension or pressure being their surface integrals. By the preceding, the mechanical force due to the stress is equivalent to dP_1/dx in the x-direction, dP_2/dy in the y-direction, and dP_3/dz in the z-direction. The resultant of these three components is the mechanical force per unit volume, and its negative is the applied force needed to preserve equilibrium, or prevent change of motion.

When, as is necessary in general, the axes of reference are not the lines of action of the mutually perpendicular simple stresses, the following notation is the most convenient. Although a tension or a pressure is not a vector in the usual sense, since it, although acting in a certain line, acts both ways, yet we may consider only one side of a stress at a time, and so represent the stress on any plane by a vector. On this understanding, let P_1, P_2, P_3, be the vector stresses per unit area on planes whose normals are x, y, z respectively. These are the forces exerted by the matter on the positive side on that on the negative side of the three planes, and being forces, are vectors. Let the scalar components of P_1 be P_{11}, P_{12}, P_{13}, &c.; and i, j, k, be unit vectors parallel to x, y, and z. Then

$$\left.\begin{aligned} P_1 &= iP_{11} + jP_{12} + kP_{13}, \\ P_2 &= iP_{21} + jP_{22} + kP_{23}, \\ P_3 &= iP_{31} + jP_{32} + kP_{33}. \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (1a)$$

(The first of a double suffix fixes the plane, and the second the direction of the force.) Here there are nine components in a general stress. But examination of the force on a unit cube arising from this stress shows at once that the transverse stresses must be equal in pairs, $P_{12} = P_{21}$, &c., if the force is to be purely translatory, thus reducing the number to six. Then, the translatory force due to the stress is

$$i.\text{div}.P_1 + j.\text{div}.P_2 + k.\text{div}.P_3\,; \quad . \quad . \quad . \quad (2a)$$

i.e., the x-component is $\text{div}.P_1$; &c.

Should, however, we admit the possibility of nine coefficients (as we may do, at least on paper, in some kinds of magnetic and electric stresses), the x-component of the translatory force is not the divergence of P_1, but of its conjugate; thus

$$x\text{-component is not} = dP_{11}/dx + dP_{12}/dy + dP_{13}/dz,$$
$$\text{but is} = dP_{11}/dx + dP_{21}/dy + dP_{31}/dz; \quad (3a)$$

a distinction which disappears when $P_{12} = P_{21}$, &c. Besides this, there is rotatory force arising from the stress, whose vector moment per unit volume is

$$i(P_{23} - P_{32}) + j(P_{31} - P_{13}) + k(P_{12} - P_{21}), \quad . \quad . \quad (4a)$$

which also vanishes when $P_{21} = P_{12}$, &c. Should this be the case, the negative of (2a) is the applied force required for equilibrium. If not, then the negative of (3a) is required to balance the translatory and the negative of (4a) to balance the rotatory force.

There are three applications of this theory of stress. The first is in the dynamical theory of elastic bodies; the second is, after Faraday and Maxwell, in the explanation of forces of unknown origin by means of stress in a medium; and the third application consists in the use of the stresses, not for explanation, but for purposes of investigation.

Thus, as from a given state of stress we derive the corresponding mechanical forces by differentiations, so we may obtain a state of stress that will produce a given distribution of force of any origin by integrations. The former is an exact process; the latter is to a certain extent indefinite; for we may clearly add to the state of stress that gives rise to certain forces any state of stress that gives rise to no forces. We should naturally choose the simplest forms that present themselves, unless there should be reasons against this. We have a choice of formulæ for yet another reason, viz., when it is not the exact distribution of force that is known, but only its resultant effect on a solid body, of which examples will occur later. We need not bind ourselves to the hypothesis that a certain state of stress really exists in a certain case, but merely use the stress vectors as auxiliary functions to assist the reasoning, if the investigations should be assisted thereby.

The gravitational application made by Maxwell requires a pressure along a line of gravitational force combined with an equal tension in all directions perpendicular to it. But the intensity of the stress is something stupendous, being at the earth's surface

$$= \frac{1}{8\pi}\left(\frac{614 \times 10^{25}}{3928.(637 \times 10^{6})^2}\right)^2 = 59 \times 10^{10} \text{ dynes per sq.cm.}$$

or 3770 tons per square inch. [Maxwell made it ten times as

much, so I give the above figures, in which I do not see any error; the unit mass is that of 3928 grams, 614×10^{25} that of the earth, and 637×10^{6}cm. its radius.] In the earth, on the supposition of uniform density, it would be proportional to the square of the distance from the centre. But a very severe mental tension is caused by an endeavour to imagine this stress to really exist. Yet the action of gravitation must be transmitted somehow.

First electromagnetic application. No objection on the score of enormously great stresses being required applies when the electric and magnetic mechanical forces are in question. In fact the method seems peculiarly fitted for their explanation. The cause of this would seem to be twofold. Gravitational matter is all attractive, and is collected in great lumps. The electric and magnetic "matters," on the other hand, are comparatively superficial affairs, and are always in equal amounts of opposite kinds. If, as some suppose, the earth is full of electricity, it might as well not be there, for all the good it does.

As a first simple application, let us confine ourselves to a portion of space in which there are no impressed electric or magnetic forces, and the dielectric capacity, the conductivity and the magnetic permeability are all constants, *i.e.*, a homogeneous isotropic medium. There are three mechanical forces to be accounted for by a state of stress.

[1.] The mechanical force on electrification. This is, per unit volume,

$$E\rho = E.\text{div}.D = pE.\text{div}.E, \quad . \quad . \quad . \quad . \quad (5a)$$

if E and D are the electric force and displacement, and $p = c/4\pi$ the condenser capacity per unit volume. It acts parallel to E, which is the force per unit density.

[2.] The mechanical force called by Maxwell the Electromagnetic force. This is,

$$V\Gamma B = V(kE + p\dot{E})\mu H, \quad . \quad . \quad . \quad . \quad (6a)$$

k being the conductivity, μ the permeability, H and B the magnetic force and induction, and Γ the true current, the sum of the conduction current and that of elastic displacement. It i perpendicular to both the current and the induction, and is in strength equal to the product of their tensors into the sine of the angle between their directions. Its existence in a dielectric is speculative, but it is difficult to do without it.

[3.] A mechanical force that we may call the Magnetoelectric Force. It is

$$4\pi VDG = VD\dot{B} = p\mu VE\dot{H}, \quad . \quad . \quad . \quad (7a)$$

where G is the magnetic current, the time variation of the magnetic induction $\div 4\pi$. Its existence anywhere is speculative, but it is absolutely needed as a companion to the last. It is perpendicular to the electric displacement and to the magnetic current. If v be the velocity, the activity of this force is

$$4\pi vVDG = 4\pi GVvD\,; \quad . \quad . \quad . \quad . \quad (8a)$$

hence $4\pi VvD$ is the magnetic force "of induction," due to the motion, the second form of ($8a$) expressing *its* activity. The existence of this magnetic force due to motion in an electric field was concluded before by general reasoning.

The magnetoelectric force can only exist in transient states. The electromagnetic force exists in steady states as well, but then there must be dissipation of energy going on. The force on electrification is independent of whether the state is steady or transient.

The forces [1] and [3] are explained by a simple Maxwellian stress, electric; whilst [2] is explained by a similar magnetic stress. A simple Maxwellian stress consists of a tension along a certain line combined with an equal lateral pressure. Let U_1 and T_1 be the electric and magnetic energies per unit volume, or $\frac{1}{2}pE^2$ and $\frac{1}{2}\mu H^2/4\pi$. Then U_1 is the intensity of the electric stress, and T_1 that of the magnetic stress. The tension is parallel to the electric force in the one case, and to the magnetic force in the other, the pressures being perpendicular to their directions.

The electric stress on any plane, defined by its unit vector normal N, is

$$(EN)D - U_1.N \quad . \quad . \quad . \quad . \quad (9a)$$

that is, a force parallel to D of intensity EN × tensor of D, combined with a normal pressure of intensity U_1. Similarly, the magnetic stress on the plane is

$$(HN)B/4\pi - T_1.N \quad . \quad . \quad . \quad . \quad (10a)$$

i.e., a force parallel to B of intensity HN × tensor of $B/4\pi$, combined with a normal pressure of intensity T_1. By taking $N = i, j, k$, in succession, we may obtain the corresponding three stress vectors on their planes. But the simple Maxwellian stress is fully defined by the single expression ($9a$) or ($10a$), according as it is electric or magnetic, N being in any direction we please.

To prove that these stresses give the required forces, it is sufficient to differentiate them. The divergence of the N-plane stress vector is the N component of the mechanical force due to the stress. Thus, the divergence of ($9a$) gives the N component of the forces [1] and [3], whilst that of ($10a$) gives the force [2]. As the transformations will occur later in a more general manner, space will not be occupied by them here. Whether these stresses be realities or not (physically), there can be no doubt as to their appropriateness.

The medium is in equilibrium in all places where there is no electrification, or electric or magnetic current. Thus in the region outside a wire supporting a steady conduction current, the stress vectors have no divergence, and there is no mechanical force arising from the stresses. On the plane containing both the electric and magnetic forces, the stress is a normal pressure, of intensity $U_1 + T_1$, acting in the line of transfer of energy. If further the electric and magnetic forces are perpendicular, as when the circuit lies in one plane, we have a tension $U_1 - T_1$ in the line of the electric, and a tension $T_1 - U_1$ in the line of the magnetic force. Lastly, if also U_1 and T_1 are equal, we have left only the previously mentioned simple pressure.

Generally, let the normal N to any plane make an angle θ with E and ϕ with H; then the force on the N plane is compounded of a normal tenison

$$U_1\cos 2\theta + T_1\cos 2\phi$$

and two tangential forces

$$U_1\sin 2\theta, \quad \text{and} \quad T_1\sin 2\phi,$$

the first being in the plane of E and N, the second in that of H and N.

There is another important case (not a steady state) in which the stress reduces to a pressure in one line, viz., in the propagation of a plane wave through a homogenous isotropic nonconducting medium. Let z be distance measured in the direction of propagation, x and y at right angles to z; then if E is parallel to x, H is parallel to y. If we look along z in the + direction, and E be + upward, H will be + to the right. They keep time together in all their variations of intensity at any place, and are of such relative magnitude that U_1 and T_1 are equal. Thus,

$$E = \mu vVHN, \qquad H = cvVNE, \qquad v^2 = (\mu c)^{-1}. \quad . \quad (11a)$$

if v be the speed of the wave and N a unit vector parallel to z. Or if E_0 and H_0 are the tensors (magnitudes, apart from direction) of E and H,

$$E_0 = \mu vH_0, \qquad H_0 = cvE_0.$$

Here, E and H being perpendicular and such that $U_1 = T_1$, the stress is a simple pressure $P = 2U_1 = 2T_1$ in the line of z. The only mechanical force arising therefrom is one parallel to z, due to the variation of P along z. This force is the sum of the electromagnetic and magnetoelectric forces, which are equal, and parallel to z, each represented by $-\frac{1}{2}dP/dz$, per unit volume.

Since the medium is not in equilibrium under the stress P, there is translatory motion in the line of z. This requires the medium to be compressible. Thus a wave of compression travels with the electromagnetic wave. The compression is, however, only an effect of, not the electromagnetic disturbance itself. Thus, in the case of a simple harmonic wave, there is a translatory to and fro motion of the parts of the medium in the line of propagation, accompanying the wave; having double ts frequency, as there are two maxima of pressure in a wave

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length. Assuming a light ray to be an electromagnetic wave of this kind, and taking the amplitude of H to be ·02 c.g.s. in strong sunlight, requiring the amplitude of E to be 6×10^8, or 6 volts per cm., and an electric current density of 240 c.g s., the maximum translatory force $-dP/dz$ parallel to z, is about 5 dynes per cubic cm. It is here supposed that the disturbance is simple harmonic, and that $v\lambda/\pi = 4 \times 10^5$, if λ is the wave length. The translatory momentum parallel to x is, in general, $2U_1/v +$ a constant independent of the time.

This motion of the medium parallel to z, not to be confounded with the internal motions of the disturbance, must react upon the electromagnetic wave. For, if v_1 be the z velocity (vector) the electric force induced by the motion is μVHv_1, and the magnetic force induced by the motion is cVv_1E; to a first approximation E and H are altered to these extents. If we compare these expressions with (11a) above, we see that $v_0N = v_1$ makes the electric and magnetic forces induced by the motion equal to the original electric and magnetic forces. This result of a uniform speed of motion of the medium in the direction of of propagation does not, however, mean more than the expression of the fact that if we travel with a wave, and at the same speed, the wave will appear stationary.

The size of v_1 depends upon the density of the medium, varying inversely with it. But v_1 is not likely to be anything but a very minute fraction of the velocity of propagation, and therefore negligible, unless we artificially increase the electromagnetic or magnetoelectric forces by passing a ray of light through a strong magnetic or electric field. Noticing that H = ·02 is quite small, we can greatly multiply the electromagnetic force by sending a ray across the lines of force of a strong magnetic field, whilst keeping its direction the same (along the ray). If, on the other hand, we send a ray parallel to the lines of force of the field, there is transverse electromagnetic force, and transverse motion produced, far exceeding the original in amount. Under such circumstances we might expect the effect of v_1 to be not negligible. These remarks, it will be noticed, rest upon the existence of the supposed stress.

(To be continued.)

SUBMARINE CABLES: THE COPPER RESISTANCE TEST.

BY A. E. BAINES.

Having examined a method by which the resistance of the gutta percha covering, or dielectric, of the cable may be determined, we now require to measure the resistance which the copper conductor offers to the passage of the current along it, for the reason that every unit of such resistance diminishes the quantity of the current in a given ratio, *i.e.*, $C = \frac{E}{R}$, where E is the electromotive force or initial pressure of the battery current, R the total resistance of the circuit external to the battery, and C the resultant current or quantity; resistance is therefore in the inverse ratio to conductibility. In the working of a submarine telegraph cable it is imperative that correct measures of this resistance should be periodically taken, because (1) the quantity of electricity required to actuate the signalling or other instruments at the far end of the line must be understood in order that the initial pressure of the sending battery may be correspondingly regulated; (2) in the event of a break the exact resistance of the conductor per knot must be known; and (3) frequent observation often enables the commencement of what may expand into a serious fault to be detected and provided for. Now, R is unalterable once the line is laid, but E is of course variable at pleasure. Before, however, we proceed with the technical details of the test which forms the subject matter of this paper, it would be, perhaps, as well to gain some further knowledge of the properties of *resistance.* If we consider running water, it will be found that the velocity of the water at the sides and the bottom of the stream is less than in the centre, and this lessened velocity is due to the resistance of the sides to the flow of water. In the case of water flowing through a cylindrical pipe the velocity of the flow is decreased by frictional resistance with the inner perimeter of the pipe, and is variable with the diameter of the pipe, the latter, like a copper wire, increasing in conductibility with diameter. Now, if this frictional resistance were not susceptible of alteration, the pressure (E) of the water would have, in order to even partially overcome it, to be increased. That is clear. Again, if we were to insert a poker in any fire, the amount of heat transmitted to the handle would vary in accordance with the length of poker (R) outside the grate, and the intensity (E) of the fire. If, therefore, we wished to make the handle hotter (or to increase C at the far end) we should have to do one of two things. Either to raise the temperature of the heat source (E), or to use a shorter poker, which would diminish R, and, as a necessary consequence, also increase C. If we wished to transmit a lesser amount of heat to the handle we should have to reverse these operations.

As regards conductibility, which is the converse of resistance, the specific conductivity of *pure* copper is taken at 100; but the copper used for telegraphic purposes is never up to that standard. It has a *lower* conductivity, and therefore a *higher* resistance. In many instances, however, its conductivity ranges from 85 to 95 per cent of that of the pure metal. To give an example of my meaning, the resistance of a wire of pure copper one inch in length, and weighing one grain, is ·001516 ohm at 60° Fahrenheit, and the resistance of any other wire of pure copper at the same temperature will be

$$= \frac{\cdot 001516 \times \text{square of length in inches}}{\text{weight in grains}}.$$

Weight being constant, the resistance of any wire varies as the square of its length, or inversely as the weight,

$$\therefore R = \frac{\cdot 001516 \times L^2}{W}.$$

Having obtained the theoretical resistance of a given wire, we have only to compare it with the actual resistance to find its conductivity.

Thus 100in. of wire weighing 1,440grs. should give a resistance of $\frac{\cdot 001516 \times 100^2}{1440} = 105{\cdot}27$ ohms; but if when tested it actually gave a resistance of, say, 110 ohms, its conductivity would be $110 : 105{\cdot}27 :: 100 : x = 95{\cdot}7\%$.

Having established the necessity of determining the resistance of the copper conductor of the cable, we will now proceed to see how this may be done. The operation is not a difficult one. We shall require, in addition to our galvanometer, battery, and testing keys, a combination of resistance coils or bobbins wound with fine, well insulated wire, and called a Wheatstone bridge or balance. This instrument has three arms, two of which are composed, generally speaking, of coils of 10,000, 1,000, 100, and 10 ohms—that is to say, each arm contains one of each of those coils. The third arm is variable, containing resistances ranging from 5,000 ohms to one ohm, there being a total of 10,000 ohms in that arm alone. Any or all of these coils can be cut out of circuit at pleasure by the mere insortion of a metallic plug in the spaces provided between each coil.

FIG. 1.

a b c resistance coils. $e_1\, e_2\, e_3\, e_4$ metal blocks to which ends of coils are soldered. *d* metallic plug with ebonite top. In Fig. 1 coil *a* is cut out of circuit; the current flowing from block e_1 through *d* (no resistance) to e_2. Coils *b* and *c* are in circuit, the current having to pass through them. Any or all of the coils can be cut out by inserting plugs as *d*.

Now, the Wheatstone bridge is nothing more than a pair of electrical scales, and for that reason, its simplicity, I have chosen the bridge method for illustration. There are, however, other ways of obtaining the resistance of a conductor. Now, having Fig. 2 before us, we will suppose that we have to measure the copper resistance of a cable (c) of 1,000 knots

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in length, the approximate resistance of which is known, from tests taken during the manufacture, to be 10 ohms or so per knot. Let a and b be the two balancing arms, in each of which we will unplug the 10,000 ohms coil, because the nearer we get to the true resistance of c in each case the more accurate our results will be, and 1,000 knots × 10 ohms = 10,000 ohms. Let d be the third (variable) arm of the bridge, and G an astatic galvanometer connected as shown. The current enters at the fork β, and divides itself equally along the arms a and b to the points δ and γ, because the resistances of those two arms (a and b) are exactly equal. If a were greater than b, a proportionate excess of current would pass through b to γ, or

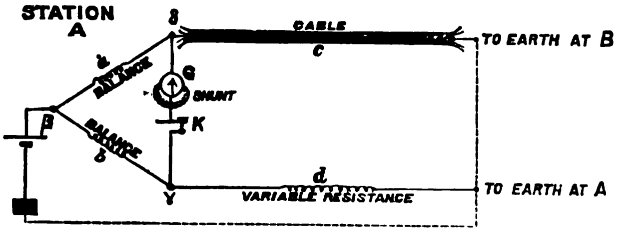

FIG. 2.

Note.—When $a=b$ and $c=d$ *no current will flow through* G. Resistance of G which gives greatest sensibility with known E.M.F. and weight of copper wire is $= \frac{(a+b)(c+d)}{a+c+b+d}$ . . . . ohms.

If balance cannot be obtained exactly, or, in other words, if difference of the fraction of an ohm in d is required to balance, then true resistance of d = lowest reading + $\left(\frac{a^0}{a^0 + a^0_1}\right)$, where a^0 is the deflection when resistance is too small and a^0_1 the deflection when resistance is too great. Example: with 11499 ohms in d the deflection (a^0) was four divisions to the right and with 11500 six (a^0_1) divisions to the left. ∴ $\frac{4}{4+6}$, and true d = 11499 + 0·4 = 11499·4 ohms.

were the reverse the case along a to δ, and the circuits a c and b d not being balanced there would be a transfer of current through G, either from δ to γ or from γ to δ, and the galvanometer would be deflected. Now, if the resistances of c and d are *also equal to each other*, no current will flow through the galvanometer from γ to δ or from δ to γ when the key K is depressed. Roughly speaking it does not matter if a and b = 10,000 ohms and c and d = 1 ohm. So long as $a=b$ and $c=d$ no current will pass through G, and a having been made equal to b, d must be adjusted by altering its resistance until the galvanometer registers no deflection upon the scale when contact is made at K. In practice, however, it very seldom happens that an adjustment can be made in submarine cable testing to the zero of the scale, owing to the presence of earth-currents, which, traversing the circuit, introduce a variable deflection which is altogether foreign to the conditions of a laboratory test. If we use a return wire from the resistance we are measuring to the earth side of d and battery, we can balance to zero; the current enters at the fork β, traverses the circuit, and returns to the battery without meeting with any disturbing influence; but it will be seen that if we insert another and smaller battery at any other point in the circuit, we shall get a deflection, due to the current from the second battery flowing through the circuit of G. If we know the number of divisions of the scale given by this extra E.M.F., we can work to that deflection and balance to it as to zero. In the case of a submarine cable it is not possible to use a return wire; the cable end must be put in connection with an earth plate at station B, 1,000 miles away, and we shall have, therefore, either to eliminate the deflections given by the earth current, or else, as is perhaps easier, to repeatedly observe and reproduce those deflections, the observations being taken both *before* and *after* the current is applied at A. Suppose, for instance, that upon closing K the earth current gave 150 divisions, proceed as follows:—Wait until the deflection is steady or has a measurable oscillation, open K and put on current sharply by depressing one lever of the battery key. Then close K by tapping. *If the earth current has not altered* and the deflection = 150, you have, presumably, a balance, but should observe the false zero again, opening K, taking off current and closing K, and should repeat the experiment with both zinc and copper currents half a dozen times to ensure accuracy. If the deflection = say 160, d must be adjusted. The extra 10 divisions may mean that d is slightly lower in value than C, or *vice versâ*, according to the sign of earth and battery currents. In such a long cable you must be prepared to find the false zero constantly shifting, and will have to take perhaps thirty or more readings before equilibrium is obtained.

The result in ohms given by d = the *total* resistance of the copper conductor of the cable, or of the whole length of 1,000 knots. To find the C R per knot, this quantity would have to be divided by 1,000.

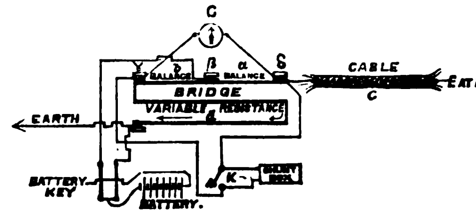

FIG. 3.

Practical connections at station A. First observe deflection given by earth current, if any, and work to that deflection in divisions of the scale as *false zero*. Put on current by depressing one lever of battery key quickly, and insert G in circuit by tapping K gently, if exact deflection given by E C is not reproduced observe false zero again, and repeat operation until it *is* reproduced. False zero must be observed *before* and *after* current is applied, to make sure that it has not altered during the preceding observation, short as it may have been. Make ratios of a and b as nearly equal as possible to resistance of C. That is if C = about 10,000 ohms, make a = 10,000 ohms and b = 10,000 ohms. If no earth current is present, adjust d until G gives *no deflection*. Use any convenient shunt to bring deflections within limit of scale, increasing the shunt resistance as equilibrium is approached. Subtract resistance of earth plate and lead from indicated resistance of d. Then corrected value of d = value of c in ohms. Divide this by length in knots for C R *per knot*.

Example: With a cable (x) of 1,000 knots in length a balance was secured when d indicated 11,500 ohms; a and b being 10,000 ohms.

Then $\frac{11500}{1000}$ = 11·5 ohms per knot, or, more properly,

$$\text{C R per knot} = \frac{d \text{ cor. for temp. and} - \text{res. of earth plate and lead}}{\text{length of cable in knots.}}$$

THE STORY OF A METEORITE.—Concluding his course of lectures on Saturday last, Prof. Dewar gave some interesting demonstrations of various laws connected with his subject. Having illustrated the periodic occurrence of showers of falling stars by means of a pendulum which left a track of fine sand, showing the intersection of the long elliptical orbit of the meteorites by the earth in its orbit, Prof. Dewar went on to give a most interesting experiment to demonstrate the attraction of the earth over small bodies coming within its atmosphere. He had at a height of about 12ft. from the floor a globe or imitation world, containing a magnet constructed by Faraday, and weighing 2cwt. With a spring tap he threw a light metal ball from one side to the other, the curve of its flight taking it near to the under part of the globe. When the ball went very near, it was drawn to the globe; if it passed too far away from the globe it was not arrested at all; if it went near enough for attraction but not near enough to be drawn up and held, it was twisted out of its course for a moment. A pendulum attached to the globe showed that the little ball also exercised attraction over the large mass. Some illustrations were given to show that the apparent approach of falling stars from one point was due to perspective, and that in reality they moved in parallel lines, and Prof. Dewar then experimented with spectrum analysis, exhibiting the characteristic colour bands of sodium, magnesium, iron, &c., in a spectrum, and then proving, by the combustion of a piece of a meteorite in the electric crucible, and by the same lines appearing in the spectrum, that those materials were contained in meteoric matter.

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THE ELECTRICIAN.

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ANSWERS TO CORRESPONDENTS.

ENGINEER.—*We have sent your letter of the 9th inst. to our advertisers, who will probably answer you direct. Personally we have no experience of the apparatus you mention.*

X. Y. Z.—*There are two books of the kind you require—one published in America; one in France. We have reason, however, to believe that a small volume is in preparation, to be published in London, which may suit you.*

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1885.

Leaving for a moment the work of private firms and public companies, we are now able to give a brief account of the progress during 1885 made by the

POST OFFICE TELEGRAPHS.—The chief event of the year in the Postal Telegraph Service is, of course, the reduction of the tariff, which came into operation on the 1st October. Its immediate effect, so far as the public were concerned, was to lower the initial charge for inland telegrams from one shilling to sixpence, the maximum of words, however, being at the same time diminished from twenty words, with an unlimited number for the addresses, to twelve words in all, addresses included. From every point of view, except perhaps the financial, the experiment has proved a success. As was predicted by the experts, the compulsory charge for the addresses, and the consequent curtailment of the telegram by more than one-half have caused no inconvenience to the public, who have quickly learnt to keep their messages well within the margin, or not far beyond it. As touching the telegraph service the traffic has been so greatly lightened by this universal shortening of messages that no difficulty at all has arisen in dealing with the additional work satisfactorily. On the whole, indeed, except perhaps at the very busiest period of middle day, the average delay is thought to be rather less now that telegrams are brief and more numerous than it was when they were fewer but much longer. At any rate, so ample had been the time allowed for the necessary preparations to meet the increase of traffic that no difficulty was experienced in coping with it either at the beginning of October or at any period since then. Naturally, the increase in the number of transactions has been very great, especially in local messages—that is to say, in messages addressed from one to another part of the same town. Notably this has been the case in London, where so complete had been the additional provisions made for local purposes that, contrary to past experience, senders find it saves time to send telegrams even over short distances within the metropolitan limits. It is too soon to pronounce decisively as to the financial prospects of the new tariff. Of course, there has been a large falling off in the revenue; but this was expected for a time, and has been taken into consideration by those who were responsible for the scheme. It has also to be remembered that the expense of delivery will be the same, or nearly the same, whether the message is short or long; but, on the other hand, the cost of transmission has been considerably reduced, two messages, or very nearly two, being now signalled in the time it previously took to signal one. On the whole, the Department and the public are to be congratulated on this important change, which has at length placed the British tariff on the rational basis long prevailing in other European countries.

The extensions and large additions to the existing lines effected in 1883-4 left little to be done in the year just ended; but some further wires have been erected, notably a new copper wire from London to Newcastle, an experiment which has proved the greatly increased working capacity of such lines. The electrical anemometer system for the Meteorological Society has also been completed. But the chief efforts of the past year were directed to the improvement and development of apparatus, the capabilities of which have been constantly expanding to meet the steadily increasing pressure of traffic. In Wheatstone simplex working alone the speed has in some instances been doubled; and for Wheatstone duplex working a proportionate increase of speed has been realised. To some remote points, such as the Islands of Jersey, Guernsey, and to Shetland, arrangements have been made so that in future any large accession of traffic on special occasions may be easily disposed of without additional wires. Many improvements in the construction and rearrangement of Repeaters on single, duplex, and quadruplex circuits have been effected with excellent results; and ordinary duplex working has been accelerated to not less than 50 per cent. On Wheatstone circuits a considerable advantage has also been gained by the introduction of a new form of Transmitter, and the substitution of single current keys for double current keys. Greater security against the effects of lightning has been insured by the adoption of a new form of protector in which mica is used as the dielectric. Some valuable improvements have been made in the pneumatic apparatus for the prevention of accidental stoppages; and a very large extension of this system with complete new machinery has recently been carried out in the Liverpool office. Pursuing the policy which has guided the Post Office from the very first no special efforts have been made to compete against private Telephone Companies for the custom of the public, and extensions in this direction have been carried out only at the solicitation of customers dissatisfied with the outside companies. But telephonic appliances are

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continually undergoing improvements at the hands of the Post Office, especially in the matter of call signals, which are now rendered effectively independent of the negligence of the user. During the past year various inventions submitted to them have been tested by the Postal Telegraph authorities. Amongst these may be mentioned some new experiments with the Rysselberghe system on the Brighton Railway; experiments with telephone and telegraph lines between London and Leicester on the system recommended by Langdon-Davies; trials with Prof. Silvanus Thompson's valve telephone; trial of Villiers, Stead, and Co.'s microphone; and some careful experimental trials with Delany's multiplex telegraph system.

Passing from the Post Office work in Telephony, we may refer to that of the

CONSOLIDATED TELEPHONE COMPANY.—This company during the past year has been very successful as regards its manufacturing business, which, as our readers are probably aware, comprises the sole right to manufacture telephones for the United Kingdom, and also the sole right to manufacture telephones for export to all parts of the world. Very considerable orders have been executed for the United Telephone Company and its subsidiary companies, the Postmaster-General, the colonies, the River Plate Telephone Company (Limited), the Telephone Company of Austria, the Edison Gower-Bell Telephone Company, the Oriental Telephone Company, the Telephone Company of Egypt, and numerous private customers. The company has also done a large business in magneto bells, trembling bells, and switch-boards. New machinery has been purchased, consisting of screw machines, drilling machines, tapping machines, and lathes of the most modern and approved type, and this, no doubt, has tended to improve the general standard of the company's manufacturers.

A patent has been taken out for an improved form of magneto bell with toothed-wheel gear and novel cut-out. The magnets in this bell are most powerful, and are now coated by means of electro deposit, with a covering of brass to preserve them from rust. The toothed gear for working the armature is constructed on the most accurate mechanical principles, and is as near noiseless as any gear can be. The new patent cut-out is arranged so that when the handle is turned it has a movement of rotation imparted to it independently of the shaft, and causes a spring to be removed from the short-circuiting contact which it made when the parts were in their normal position, so that when the crank is turned it throws the armature in the circuit whilst the crank rotates, but as soon as the crank-handle is released the spring piece attached to the crank automatically returns to its original position, and touches a metal ring let into the side of the case, thereby short-circuiting the coil of the magneto armature.

The bell cases are made of specially selected and well-seasoned American black walnut, dovetailed by special machinery. The company guarantee this magneto bell to ring well through 15,000 ohms, and it can be adjusted to ring through 50,000 ohms. Improvements have been made in the consolidated telephone, for which the company holds the patent. Amongst them we may mention the substitution of an open for the closed top microphone. It not only overcomes the objection some people have of using the telephone immediately after another person, but it gives far better results, and has met with greater favour. A magneto call, with all the improvements above described, and its attendant saving of batteries, is fitted into the case containing the transmitter. Under the supervision of the Postal Authorities considerable improvement has been made in the Gower-Bell telephone.

A telephone, specially adapted for use in *wet* mines has been invented, and for some time past has been successfully used in Cornwall. A forward step in this company's divers' telephone apparatus has been made in the substitution of a Consolidated for a Blake transmitter, as the former, requiring no adjustment or attention, is of great service to those users who have not a sufficient technical knowledge to attend to the many requirements of the Blake instrument.

Another manufacture worthy of attention is a new pattern of switch-board which is compact, easily workable, and capable of being enlarged as the requirements of an exchange become greater. It is possible for one operator to connect three subscribers in a minute by means of this board.

On the whole, the Consolidated Telephone Company has made a great stride forward in the year 1885. Its subsidiary companies—the River Plate Telephone Company, the Telephone Company of Austria, and the Edison Gower-Bell Telephone Company—have each added largely to their numbers of subscribers, which, at the moment of writing, must be over 4,400, and are steadily and surely increasing each week.

The firm of FELTEN AND GUILLEAUME, of Mulheim-on-Rhine, near Cologne, Germany (for whom Messrs. W. F. Dennis and Co., of 101, Leadenhall-street, E.C., act as agents), have been fairly well employed in all their departments during the past year, another proof of the ingenuity and activity displayed by the firm, when it is considered that others of similar branches are absolutely lacking work and dismissing their staff. Messrs. Felten and Guilleaume have continued to supply heavy contracts of telegraph and telephone wire in their favourably known qualities of iron and steel, both for Continental and other Governments. In telegraph cables they have also had some good orders for underground and river work, cables of their manufacture having frequently been sent across the Atlantic during the year. However, the most noteworthy feature for the past year is the rapid progress Messrs. Felten and Guilleaume have made in the construction and manufacture of telephone cables.

The construction of suitable telephonic cables is one of the most important questions involved in modern electrical science. Great as has been the development of telephony throughout the whole world, it has been universally recognised that until recently its application was by no means perfect. With the steadily increasing number of subscribers in large towns it has become impossible to place the wires required to connect the subscribers. When only a few subscribers were connected to the exchanges, it was an easy thing to conduct the wires over the roofs, in the same manner as telegraph wires are frequently put up, by means of porcelain or glass insulators fixed on poles. But when thousands of wires are to be put up and made to converge into one central point, this easy system is no longer applicable, and the only substitute possible is that of cables, either underground or aerial. Hence, the universal cry for telephone cables which has been a prominent feature in all our electrical papers for several years past. Now, it is easy to combine even a very large number of insulated wires into cables, but to construct a telephone cable that will work is a matter of considerable difficulty, owing to induction, retardation, and other phenomena; but Messrs. Felten and Guilleaume have succeeded in at least largely overcoming these difficulties, as will be seen from the fact that during the past year they have manufactured and laid considerable quantities of telephone cables, which have not only answered, but exceeded all expectations, both in Germany and in other countries, including England. Thus, at the end of 1884, Messrs. Felten and Guilleaume had put up at Munich about 2,800 yards of aerial telephone

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cable suspended by means of a carrier wire. The Royal Bavarian Telegraph Department pronounced this cable (consisting of 27 conductors) as "free of induction and retardation," and "giving entire satisfaction." The result of this experiment was a further order for about $4\frac{1}{2}$ miles of 27-conductor telephone cable, to be laid underground at Nuremberg. This was done in June, 1885. The cable, laid in iron casings, was put in operation in August, with the same good results, the Royal Bavarian Telegraph Department having since expressed their entire satisfaction, and acknowledged the "excellent quality and efficiency" of these cables. During the same time the Imperial German Telegraph Department, having obtained similar good results with about seven miles of 27-conductor underground telephone cable of this company's manufacture, decided on another order of about nine miles of the same cable, which has since been executed by the firm. The department certifies that the cables give "every satisfaction," and that the "excellent results" obtained with the first lot have decided the second order.

The Copenhagen Telephone Company reports in June, 1885, that having had in continual use for six months without disturbance or accident a total length of about $1\frac{1}{2}$ mile of Felten and Guilleaume's aerial telephone cable, and this experiment having had the most satisfactory results, they have decided to order another twelve miles of 27-conductor telephone cable, the major portion of which would be laid underground. These twelve miles were laid in October, and are now, after having been in operation for some time, pronounced to be a complete success. The cables are so arranged that up to $5\frac{1}{2}$ miles of cable are spoken through, but sometimes about six miles of ordinary line are connected to the ends of the cable, so that it often happens that about 12 miles of cable and wire are spoken through. Nevertheless, the transmission of voice is excellent. A further addition of fresh cables to the system is planned.

Mr. Madson, director of the Copenhagen Telephone Company, recommends Messrs. Felten and Guilleaume's cable as "most efficient, and satisfying all conditions of the telephonic service." A further length of about 7 miles of 27-conductor telephone cable has been supplied in the latter part of the year for the Swiss Telegraph Department; also about $3\frac{1}{2}$ miles of 52-conductor cables for a Canadian Telephone Company, and last, not least, about $1\frac{1}{2}$ mile of 27-conductor cable for a telephone line through the newly-finished Mersey Tunnel, all of which gave entire satisfaction. All these cables are lead-covered, having a double impermeable but light lead-covering, and are insulated with a compound of their own, which gives the highest possible insulation, and renders the cable uninfluenced by heat. In using other kinds of telephone cables it has been observed that when a telephonic line was composed partly of such cables and partly of open aerial wire lines, the retardation was so strong as to make speaking through such lines nearly impossible. At the request of the Imperial German Post Office experiments have been made lately with Messrs. Felten and Guilleaume's telephone cables on a line composed of about six miles of their cable connected with thirty miles of open wire line. These experiments have proved that even on such long lengths retardation was practically absent, and that these cables answer perfectly for all telephonic lines.

Continuing our remarks upon Electric Lighting, we come to the work carried out by the ANGLO-AMERICAN BRUSH CORPORATION, which during the past year comprises much of importance as bearing upon the application of electricity to various industries in the future. The thorough manner in which its installations have been designed and carried out has contributed in no small degree to the revival of confidence in electric lighting which is now beginning to be felt by the public. Much has been done during the past twelve months towards perfecting the various kinds of electrical apparatus manufactured by the corporation, who hold the unique position of being the only firm in this country supplying both high and low tension dynamos, and arc and incandescent lamps manufactured by themselves. The exceptional facilities thus offered to improvement in combinations of plant used in every branch of electric engineering have been thoroughly utilised by the company. The high reputation which the Victoria dynamo has earned ever since its practical introduction has during the past year been fully maintained. This machine has been extensively employed by the home and foreign Governments for both naval and military purposes, and it is now a well-recognised article of commerce. The various other accessories to electric lighting, such as projectors, signalling, and torpedo search apparatus have been largely used.

The introduction of slow speeds for both engines and dynamos, for which the facilities offered in this direction by the construction and form of the Victoria dynamo have been in a great measure responsible, has resulted in reliability of working on board ship, which is being recognised throughout the mercantile marine, and has imparted an additional impetus to the electric lighting of passenger steamers. Considerable attention has also been paid by the above company to motor work, and motors of large powers have been supplied both at home and abroad to work in conjunction with Brush machines of high tension to transmit power over long distances. The Brush dynamo and arc lamp, in which important modifications have been made, still continue to hold their own. It is hoped that ere long a practical and extended application of their use may be seen in the metropolis on a scale somewhat like that adopted across the Atlantic. Foreign contracts have constituted no inconsiderable portion of the Brush Company's operations during the past year; but among home firms to whom, or localities where plant has been supplied or installations successfully carried out may be mentioned the following:—The Central Station at Glasgow, and the Grangemouth Station and Docks, for the Caledonian Railway Company; the Waverley Station at Edinburgh, South Kensington Museum throughout with the new Brush-Sellon lamps; Holloway Sanatorium at Virginia Water, the Woking Convalescent Home, Messrs. Ritchie and Co.'s Mills, Stroud; the Duke of Bedford's yacht "Northumbria," the yacht "Christine," the Newbottle Colliery, and others. Many similar contracts are in hand for the coming year, amongst others the lighting of a portion of the Colonial and Indian Exhibition.

The past year has not been an uneventful one for this corporation. Besides the completion of important schemes initiated with the view of extending the scope of the company's business and influence, it has been made evident from the extensive and successful work carried out that during the past year the company has, in a commercial sense, turned the corner. The past year has also witnessed many important changes in the composition of the board of directors. In the early spring the company lost, by the death of Mr. Ladd, the services of one of its original directors and the co-operation of one of the earliest workers in practical electric lighting. As a result of the amalgamation with the Great Western Electric Light Company, the corporation secured the services of Mr. Braithwaite as a director, and later in the year Lord Sudeley

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and Major-General Webber, C.B., accepted seats at the board, the latter doing so in the capacity of managing director.

Our notes upon the work of 1885 have run to an unusual length, but we must keep the concluding portion for another week.

CORRESPONDENCE.

THE ECONOMICAL DISTRIBUTION OF CURRENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In one of the lectures by Prof. Geo. Forbes, printed in *The Electrician* of November 6th last, it is stated that the "three-wire system" of distribution of current is not so economical as has been given out here in America—that is to say, that there is no such saving as that of 62 per cent. of the copper required for the "two-wire system."

Being connected with one of the Edison companies, I feel it necessary to contradict that statement and prove it to be otherwise; and being an Englishman myself your readers need not take this as a mere defence of a "purely American idea," but a truthful representation of facts as they ought to be understood.

Putting aside the "three-wire system" for the moment, there is a very simple rule in regard to the advantage of increasing the potential in saving of copper. It is that the quantity of copper required to transmit a certain amount of electrical power (watts) at a given loss (or per cent. of loss) varies inversely as the square of the potential.

In the three-wire system we have an extra middle wire; but assuming the current is balanced, neglect this, and for doubling the potential we require, according to this rule, only 25 per cent. of the copper required for the two-wire system. Now, add one wire equal to one of the other two—that is, add 50 per cent. to this 25 per cent., or $12\frac{1}{2}$ per cent., this makes $37\frac{1}{2}$ per cent. of the copper required, or a saving of $62\frac{1}{2}$ per cent. This can be still further increased to 69 per cent. by using a one-half sized wire for the middle or neutral wire, which is quite sufficient.

For an example take 100 lamps of 90 ohms each, and on the two-wire system first. Then the resistance of all these lamps in multiple arc would be $\frac{90}{100}$ or ·9 ohm. If, now, we like to lose 10 per cent. in the line to the lamps (assume the lamps to be all at the end of the line for simplicity), the resistance of the line will be of course 10 per cent. of the total resistance of the circuit, or ·1 ohm. The total resistance, then, of the line and lamps is 1 ohm.

On the three-wire system there would be two sets of 50 lamps in multiple arc, each 50 would have a resistance of $\frac{90}{50}$ ohm (90 ohm lamps), or 1·8 ohm, and the two sets in series would be 3·6 ohms, or four times the resistance of the lamps arranged on the two-wire system. A line to lose 10 per cent. of the potential, therefore power, on this circuit would be ·4 ohm, making a total resistance of the circuit (line and lamps) of 4 ohms.

Instead now of having two mains of ·1 ohm we can use two of ·4 ohm, which must, therefore, only be one quarter of the section of the others, and so only 25 per cent. of their weight. Now add a middle wire, or $12\frac{1}{2}$ per cent., and we arrive at the same conclusion as before.

Any one acquainted with Ohm's law can make this out by putting it on paper, though I can easily understand that at first sight it may look very much as if reducing the current to one half you require one half the section of wire.—Yours, &c.,

New York, Dec. 31, 1885. HENRY E. WALTER.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad your correspondent, Dr. Stone, has given vent to his thoughts on this subject. He is unknown to me, but the idiosyncrasy of his mind is common to that of many eminent writers on electricity. When a series of facts about electricity are laid before them, they see those of the facts which are in favour of their theory of electricity, but they are blind to or will not admit into their minds the facts which tell against their theory of electricity.

My letter as printed in your pages occupied twenty-five lines. One of these has alone made an impression on Dr. Stone's mind, "the carpet and the bare feet," whereas the last thirteen lines of my letter are about an electrical phenomenon which has not on any previous occasion been laid before the public in print.

Will Dr. Stone be so good as turn his attention to it and give his explanation of it through your pages?—Yours, &c.,

JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, 9th Jan., 1886.

THE SCIENCE OF ELECTRICAL ENGINEERING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with great pleasure the excellent remarks of Mr. Walker in the last issue of your esteemed paper.

Allow me to say one word with regard to "There is no mystery about electrical engineering."

A few days ago I was told by the *manager* of the works I am in not to tell the men too much, as there was nothing in electrical engineering; any one could pick it up.

The same manager said to a young fellow who wished to go outside and learn the installation work, "There is nothing to learn; all they (those engaged on installation work) know, you can pick up in half an hour."

The above facts speak for themselves, and need no comment of mine.—Yours, &c.,

A YOUNG ELECTRICAL ENGINEER.

RESISTANCE AND CONDUCTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you, or some of your readers, kindly acquaint me with the difference in resistance and conduction between a solid bar and a hollow cylinder of copper, both being of the same length and diameter? As regards the thickness of the cylinder any convenient numbers will do. On the one hand I am told that electricity flows *over a surface*, and on the other that conductivity is in the inverse ratio to sectional area. These two statements rather confuse me.—Yours, &c.,

TYRO.

THE DYNAMO AS A GENERATOR AND AS A MOTOR.*

BY W. M. MORDEY.

During the last few years an immense amount of attention has been given to everything relating to theory and practice of dynamo machines. So thorough has been the study of the problems connected with these machines, which are of a character to appeal both to the physicist and the practical constructor or engineer, that it is now not difficult to lay down, in a fairly complete form, the laws governing their action, and the rules and principles under which they should be constructed, although three or four years ago much confusion and uncertainty existed as to what was best in dynamo construction.

But in electric motors the case is very different. While it is easy to name physicists and constructors in considerable numbers who hold clear and correct views on the subject of electric generators, it is by no means easy to find definite and correct explanations of what is right and what wrong in regard to the allied subject of electric motors.

And on no point does there appear to be greater uncertainty than on that of the analogies and the differences between the two machines. For instance, while it has been proved beyond question that in dynamos the most economical and best working conditions are obtained by employing field-magnets of great magnetic strength, and armatures which are relatively

* From the *Phil. Mag.* for January.

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very weak magnetically, the only definite assertion within the writer's knowledge given with authority on this point asserts the contrary to be the case with motors—that the fields should be relatively much lighter and weaker than the armatures*.

Again, what can be more striking than the great and known difference between dynamos and motors in respect to the very important matter of efficiency! Almost any modern generator will give a return in the form of electric energy of 90 per cent. of the mechanical energy expended in it, and a useful yield of over 80 per cent. in its external circuit. In the case of the best generators this is a considerable understatement of the working conditions. With electric motors, on the other hand, one has to be contented with a much lower efficiency. The energy supplied to them is severely taxed in the process of conversion. Motors frequently yield, as mechanical energy in a useful and available form, only 30 per cent., and seldom more than 60 per cent., of the electric energy absorbed.

The reversibility of the dynamo, or its ability to work either as generator or motor, has been spoken of as one of the most important discoveries of late years (the great physicist credited with the expression of this opinion having apparently overlooked the fact that Pacinotti made his famous machine as a *motor* in the first place). But the fact that a given machine which will work well and efficiently as a dynamo, will not work so economically when its action is reversed and it is made to act as a motor, is a proof that the reversal is accompanied by some radical change in its action. This difference, where it is noticed at all, is generally sought to be explained by an assertion or a supposition that having been designed and made for one purpose, it was therefore not suitable for the other. No satisfactory explanation, as far ss the writer is aware, has been given of the cause of this lower efficiency of motors, or, in other words, of how the missing power is expended. In what particulars a good motor should resemble a good dynamo, and in what they should differ from one another, are also interesting questions of great importance which await answers.

The writer having, with Mr. C. Watson—who is his assistant in the works of the Anglo-American Brush Electric Light Corporation—given some attention to the matter from a practical point of view, a great necessity was felt for some foundation on which to work, similar in character to the broad general principles which serve to guide the practical constructor of dynamo machines. In the search for such general principles, all those ways of considering the actions which depend on the idea of magnetic poles in the armature were abandoned, and the conclusion was arrived at that the armature should have no polar action whatever, that the iron of the armature should have only the function of a conductor of lines of force and that the power of the motor should be due to the simple action between the lines of force of the magnetic field and the armature wires conveying currents at right angles to those lines of force. This mode of regarding motor action is convenient on several grounds, and leads to certain conclusions, which, if correct, form substantial bases for practical construction. Thus the armature, instead of being as hitherto considered as a strong electromagnet placed in the field of another electromagnet, is to have its electromagnetic functions reduced as much as possible, or preferably suppressed altogether.

The field is to be very strong.

As with such an arrangement there is no polar effect in the armature except that due to the direct magnetic induction of the field-magnets, it follows that the maximum power is obtained with any given current when the brushes occupy an absolutely neutral position, or, in other words, when there is no "lead" and no distortion or rotation of the field. These conditions do away with the most troublesome and prolific cause of the sparking at the brushes, which is so often an objectionable feature of most electric motors.

But by working backwards in this way it was seen at once that the conditions which seemed to be best for a motor were precisely those which the would-be designer of a perfect dynamo would set before him as his goal.

* Profs. Ayrton and Perry, "Electromotors and their Government," *Journ.* Soc. Teleg. Eng. and Electricians, March, 1883.

Certain perfect analogies had been arrived at. In both dynamos and motors, according to this briefly-sketched view:—

(1) The field should be a very strong, the armature a very weak electromagnet.

(2) In both generators and motors "lead," distortion, or displacement of brushes or of magnetic field is wrong, and is to be avoided by attention to (1).

Whatever "lead" there may be in either case, there is this difference, that in dynamos this "lead" is in the direction of rotation; in motors it is in the opposite direction, as the course of the current through the armature is reversed, but the field is the same.

(3) In both generators and motors absence of sparking at the brushes depends mainly on the conditions of (1) being complied with.

(4) Reversal of rotation. In neither generators nor motors is movement of the brushes necessary.

But having got so far, a little consideration suggested the probable existence of another analogy. Since a dynamo having the above theoretically perfect form and action, with a constant field would produce a constant electromotive force if run at a constant speed, independently of the load or amount of current generated, a motor constructed on the same principles and having a constant field, if supplied with energy at a constant difference of potential, should run at a constant speed, independently of load.

If this should prove to be a true analogy, a simple means of obtaining results of great use in the practical application of electricity would be obtained—results which have been sought in many directions, more or less complicated, without any great success.

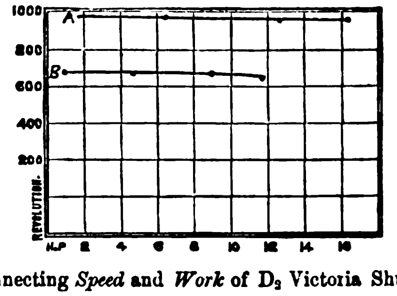
By permission of the Anglo-American Brush Electric Light Corporation experiments were carried out in the testing room of their works with a Victoria dynamo. The results ultimately obtained, which are given in the following tabulated account of the experiments, and in the curves plotted for them, show that this fifth analogy is as true as the preceding ones, a constancy of speed being obtained which was very remarkable —even when the load was increased, until much more than that which as a generator was usually considered the full working current was traversing the armature.

Two sets of readings were taken, working up to about the same current in each set, but with the potential-difference of the supply different in the two cases, as stated. The field was of the same strength throughout. The load consisted of another Victoria dynamo driven through a modified White's transmission-dynamometer, the work being varied as required by altering the external circuit of this dynamo.

Experiments with a D_2 Victoria Shunt Motor at Constant E.M.F.

Speed.	Current.	Difference of potential at terminals.	H.P.*	
975	36·3	140	1·8	Curve A. Maximum speed variation 3 per cent.
965	66·5	,,	6·6	
948	97·1	,,	12·87	
945	130·8	,,	16·3	
680	29	100	1	Curve B. Maximum speed variation 3 per cent.
677	61·4	,,	4·8	
675	102	,,	9·14	
660	123	,,	11·7	

* Including an unascertained loss in transmission.



Curves connecting *Speed* and *Work* of D_2 Victoria Shunt Motor.
With supply at constant difference of potential.

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At first it appeared that the counter electromotive force of the motor was dependent neither on speed nor strength of field, as the latter was constant and the former very nearly so, while the current rose with the work; but calculation showed that this was not the case, indeed it could not be so.

Let us call the counter electromotive force e, and the loss of potential caused by the resistance of the armature e_1, and the difference of potential at the terminals E. Then

$$e + e_1 = E.$$

Calling the current C, and the resistance of the armature R, we know that

$$e_1 = C R.$$

The resistance of the armature of the motor in question was ·027 ohm, which we will call ·03 in order to make some allowfor the effect of heating.

In the first and last readings of the second set of tests (curve B) we have, therefore, the following conditions:—

Speed.	e_1.	e.
680	·87	99·13
660	3·75	96·25

Now $$\frac{680 \times 96{\cdot}25}{660} = 99{\cdot}13.$$

From which it appears that the counter electromotive force was exactly proportional to the speed, as is to be expected where the field is constant and the magnetic distortion *nil*.

The other cases do not work out with the same accuracy. The results are, however, quite within the limits of error inseparable from the rather rough conditions of these workshop tests.

One other fact may be pointed out in connection with these tables of results and curves. In the case of dynamos working with a constant field, the output with the same current is almost exactly proportional tc speed, as the E.M.F. is also simply proportional to speed. So with the motor, the speed is proportional to the E.M.F. of supply; and the work, with the same current in the two cases, is simply proportional to speed, therefore to E.M.F.

With regard to the theory alluded to above, that in a motor the fields should be much weaker and lighter than the armature, it may be pointed out that in this, as in the other points mentioned, there is a real analogy between motors and generators, inasmuch as, according to the views briefly expressed in this note, such a motor, although a bad one from most points of view, would have a certain advantage in that for its weight it would do a good deal of work. Similarly, dynamos may be, and have been built, which, although far from efficient and reliable, will give a large output for their weight. Their construction is, however, scarcely to be recommended on this ground, except, perhaps, under very exceptional circumstances; and they, as well as the motors constructed on the same lines, appear to be instances of a mistaken apprehension of elementary principles.

Having briefly traced the analogies between generators and motors thus far, the subject may be dismissed for the present with the remark that a further consideration of the matter serves only to reveal the fact that in almost every phase of their actions the two machines afford further opportunities of a direct comparison.

Turning now to the question of efficiency alluded to above, it is evident that there is some important cause of loss or waste of energy in electric motors which is absent in generators. This has always been a kind of *lacuna* in the explanations of the action of motors; and in order to localise the loss and to ascertain its cause, the several possible sources of waste were carefully considered. These are:—(*a*) Friction at the bearings, air-friction, and friction of the brushes against the commutator. (*b*) Loss of energy in heating the armature and field conductors, and a certain loss due to self-induction. (*c*) Loss by the production of eddy-currents in the iron.

Now it is evident, especially with a generator or motor having the qualities sketched above, that at the same speed, and working with the same currents in its conductors, the losses under (*a*) and (*b*) must be identical, whether it be working as a generator or as a motor. And as with such conditions its efficiency as a motor is lower than as a generator, the cause of the loss must be sought under (*c*), *i.e.*, the eddy-currents in a dynamo must be less than in a motor, all other conditions being the same. And such is the case, the explanation arrived at by the writer and Mr. Watson being a very simple one.

In a dynamo the rotation of the armature causes eddy-currents to be generated in the iron core, in the same direction as in the conductor proper with which the core is surrounded. Of course, as the armature is always more or less subdivided or laminated in a direction at right angles to the lines of force, any circulation of currents round the core is avoided; but local currents, which are aptly called eddies, are set up, and, taken as a whole, these eddy-currents on the outside of the core are in the same direction as the current flowing in the copper conductors.

In an electric motor, however, the eddy-currents and the currents in the copper conductor are in opposite directions; as, although the E.M.F. set up in the conductor is in the same direction in a motor as in a dynamo, the current in the former is forced through the armature in a direction contrary to the E.M.F., or opposite to its course in a generator. According to the laws of induction, therefore, it will be seen that while in a dynamo the two sets of currents, those in the iron and those in the conductor, tend to oppose and to reduce one another, in a motor they act in such a manner as to mutually assist each other. Thus, with the strength of field, the current in the conductor, and the speed the same in the two cases, it will be seen that in a motor the eddy-currents in the iron core of the amatures will be greater than in a generator, and therefore the heat-loss in the former will be more than in the latter. There is little doubt that this is the cause of the lower efficiency of motors than of generators; and it points to the advisability of giving even greater attention in the former to those principles which are well understood for the reduction or elimination of eddy-currents.

DYNAMO TESTS.

(Continued from page 176.)

Calorimeter Calibrations.—The calorimeter has been described. In making the observations, the time the mercury crossed each half degree or centimetre of the thermometer was taken as the mean of the times of crossing the tenths before and after the division, and the division itself. In calculating the water equivalent of the calorimeter, the weight of the shaft was multiplied by the specific heat of steel; that of the cylinder by the specific heat of copper, and the weight of the glass and wire by their specific heat. For steel, the value of the specific heat was assumed to be ·1110, and that of copper ·0940.

The principal correction to be applied is due to radiation. The other corrections are for rise of temperature from stirring, for the part of the thermometer stem in the air, and a small one for weighing in air.

The coefficient of radiation was determined by noting the rate of cooling, the calorimeter being slowly stirred. Experiments gave

Difference between air and calorimeter,	10° C. 1	coefficient,	·00154
,, ,, ,, ,,	5° C.	,,	·00150
,, ,, ,, ,,	0° C.	,,	·00149

Before the experiments, and for the determination of the radiation, the cylinder was carefully polished.

The correction for stirring was determined by bringing the calorimeter to exactly the temperature of the air, and then turning the wheel belted to the pulley on the shaft three times per second. The rise of temperature was ·02° in five minutes. For the smaller velocity used in the later experiments, the heating was assumed to vary as the cube of the velocity.

The correction for the temperature of the stem was taken from

$$c = {\cdot}000156\, n\, (t - t')$$

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The following is one of the calibrations :—

Calorimeter Observations. *Observers* : { Anderson, Duncan, June 20th, 11:40 A.M.

Time of passing 1 Centimetre.	Temperature of Calorimeter.	Temperature of Air.	Absolute Temperature of Calorimeter.	THERMOMETERS.
	CM.			
31–19·8	17·50	27·	24·129	For calorimeter, Hicks No. 108947.
32–35·7	18·	26·9	24·826	For air, Green No.
33–52·3	18·50	26·8	25·523	
35–08·3	19·	26·9	26·221	Water equivalent of calorimeter, corrected
36–23·8	19·50	26·9	26·918	for weighing in air
37–41·3	20·	27·0	27·618	=8·4311 kilos.
38–56·7	20·50	27·3	28·316	Value of mechanical equivalent used,
40–14·2	21·	27·4	29·015	(corrected for Latitude)
41–29·7	21·50	27·6	29·713	=425·75
42–46·2	22·	27·7	30·411	

Current : Wyckoff Observer. Potential : Murdock Observer.

Deflection.	REMARKS.	Deflection.	REMARKS.
17·56	R=40	10·27	R=50,000
·56	t_b 23·°	·26	t_b=22°
·53	t_s 22·4°	·26	
·56	t_g 24·°	·26	
·54		·25	
·56		·27	
·54		·26	
·53		·24	
·51		·28	
·48		·26	
·50		·27	
·47		·29	

In making the calculations, Rowland's value of the mechanical equivalent was taken, because the thermometers used in the above experiment were compared directly with those employed by Prof. Rowland, and thus errors in thermometry were to a large extent eliminated. The following are the calculations for the observations :—

INTERVAL.	Corresponding Interval in Degrees.	Corresponding Interval of Time.	Degrees per Minute.	Same Corrected for Radiation.
centimetres.		min. sec.		
17·5 to 20·	3·489	6 21·5	·5488	·5473
18· to 20·5	3·490	6 21·0	·5496	·5490
18·5 to 21·	3·492	6 21·9	·5486	·5487
19· to 21·5	3·492	6 21·5	·5492	·5502
19·5 to 22·	3·493	6 22·5	·5479	·5497
			Mean :	·54898

Rise per minute, ·54898
Correction for stirring, − ·00044
Correction for stem, + ·00140

Corrected rate, ·54994

C^2 R log, 9·517206
R log, 9·038541

C^2 log, ·478665
C log, ·239332
K_c ·02450
K_{50} ·1847 @ 22°

Probably the greatest source of error in the calorimeter experiments was the superheating of the wire in the water. Using platinum iridium wire varnished, with a smaller current than was generally employed in these experiments, Mr. L. B. Fletcher calculates* that the superheating is about 2° C. But in the measurements described above the wire was bare and the flow of water past it very much faster than in Mr. Fletcher's work. In the last two experiments a rise of 2° C. would cause an error of less than one-tenth per cent., so it is probable that they are not much affected by this source of error.

* American Journal of Science, July, 1885.

It is also possible that there was conduction through the water. The calorimeter was carefully cleaned before each experiment and distilled water used. If such an effect existed, it would be in an opposite direction from the superheating.

The usual range of temperature was 10° C. ; in the experiment given it was a little over 6°.

Besides the regular calibrations, the constant was calculated after each test, from the potential at the extremities of the German silver "dead resistance," the current being measured by the current galvanometer, and the resistance measured by the bridge. The following partial list of calibrations excludes measurements made in this way. It includes the time during which most of the tests were made—from June 11th to June 23rd :—

DATE.	Value of K_{50}.	Constant used.	METHOD.
June	at 25 degrees.	at 25.	
11	1·845	1·847	Voltameter.
11	1·8465	1·847	Voltameter.
12	1·847	1·847	Voltameter.
12	1·847	1·847	Voltameter.
13	1·844	1·844	Voltameter.
14	1·842	1·844	Voltameter.
16	1·843	1·844	Voltameter.
17	1·843	1·844	Voltameter.
18	1·845	1·844	Voltameter.
19	1·8434	1·843	Calorimeter.
19	1·844	1·843	Voltameter.
20	1·8485	1·843	Calorimeter.
22	1·843	1·843	Voltameter.
23	1·843	1·843	Voltameter.

For the Edison Nos. 5 and 10 dynamos, the potential galvanometer was in the same position as when used for the duration test of lamps, in a room at some distance from the test house. Before the machine was run on the partial loads, the galvanometer was taken to pieces, the coils rewound and soaked in paraffin, and the stand of the tube carrying the suspension more firmly secured. A beam, which pressed against the wooden pier, was also cut away. After this, the constant did not vary, the calibrations rarely differing more than one-tenth per cent. from the constant used.

(To be continued.)

THE LATE SNOWSTORM AND OVERHEAD WIRES.

At the meeting of the Metropolitan Board of Works on the 8th inst., mention was made of the serious consequences arising from the failure of the fire alarm telegraph circuits last week owing to the destruction of overhead wires by the snow. It was also resolved that the Works Committee should "inquire and consider as to the facts relating to the recent accidents to overhead telegraph and telephone wires, and the danger to the public therefrom, and to report thereon, and as to the necessity of any proceedings or future legislation on the subject, and that the surveyors to the vestries and district boards be requested to supply the Board with information which they have." On the motion of Mr. Selway, the report of the Works and General Purposes Committee was received. It recommended that the United Telephone Company be informed that the Board, having again given consideration to the matter of the erection of their telephone poles, are unable to depart from their previous decisions, declining to accede to the Company's requests.

On this subject the *Daily Telegraph* remarks : "In the course of the parliamentary investigation last year, Lieut.-Col. Haywood, engineer to the Commissioners of Sewers, stated that within the last ten years 320 wires had been carried across Moorgate-street and 240 across Leadenhall-street. In Cannon-street there were seven cables and 360 wires, and in Fleet-street from one spot in Ludgate-circus one could count 142 wires and two cables. Taking the mean roughly, this number was at the rate of 1,000 wires per mile. This average has since then been exceeded. With regard to the durability of a line there seems to be some doubt, but it is asserted that the risk is increased in proportion to the number of wires.

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At present there is no authority with legal control over the telephone companies. In the case of the Wandsworth Board of Works against the United Telephone Company, it will be remembered that the Court of Appeal decided that so long as the wires were not proved to be a nuisance, that is to say, to be dangerous to life or property, the local board had no veto upon the erection of a wire across the road. In this respect legislation is said to be wanting. Lieut.-Colonel Haywood offered the opinion that there ought to be in all the more densely-inhabited parts of the metropolis, large subways, such as the Corporation constructed in the Holborn-viaduct, and in some of the side streets, in which not only telegraph wires, but gas and water pipes, and those of the electric lighting companies should be placed. With respect to the last named, it is quite certain they could not be tolerated in proximity to the telegraph cables. It was entirely owing to the fact that the bulk of the General Post Office wires in the London district are now conveyed underground that there was not a complete breakdown during the snowstorm and since. At points and in some of the suburbs where open lines are in use, the fall of telephone wires rendered them useless, but no such interruption occurred in the metropolis generally. On Wednesday there were actually transmitted from one part of London to another 13,936 messages, the largest number ever despatched in one day, the average since the introduction of the sixpenny rate having risen to nine or ten thousand from five or six thousand."

The Chairman of the Parliamentary Committee above referred to, Mr. G. W. E. Russell, writes to *The Times* as follows :—

"Sir : In Mr. Beachcroft's letter about overhead wires he refers to the report presented by the Select Committee, of which I was chairman. Permit me to say a few words in self-defence. After a careful examination of exhaustive evidence, the committee did not feel justified in recommending the total discontinuance of overhead wires. But, in the draft report which, as chairman, I proposed to the committee, I urged the following precautions :—All overhead wires should be subject to proper supervision. Overhead cables should not be permitted. Where more than ten wires are run along a line, the local authority should have power to compel them to be taken underground. The local authority should also have power to regulate the length of span and other conditions necessary to secure the safety of the public. No power to pass and keep wires over private property without the consent of the owner or occupier should be given to any company or private person. All owners of land or occupiers of houses should have power, by notice to the local authority, to cause the removal of wires crossing their property and belonging to any company or private person. No company or private person should have power to make attachments to houses or buildings without the consent of the owner or occupier. By-laws for the regulation of all wires as to substance, length of span, durability, &c., should be made for the whole of London by the Metropolitan Board of Works. Every wire should be registered with the local authority, and all ownerless wires be removed. The duty of inspecting wires and maintaining them in proper order should devolve on the owners, who will be responsible for the results of neglect. These precautions were rejected by the majority of the committee, and a report was presented, inconsistent, in my judgment, with the public safety and the rights of private property."

Commenting on the above letter Mr. G. Layard, of 5, Fenchurch-buildings, suggests that if those local authorities who are desirous of obtaining more ample powers for dealing with these wires would at once take steps (before the circumstances are forgotten) to obtain and record the particulars of all which have fallen in their districts during the last few days, whether resulting in injury or not, they would accumulate a mass of evidence which would be readily available for securing the desired result.

The *Saturday Review* thinks that "If only every winter had its snow, and plenty of it, there were hope for the long-suffering Londoner. Then, perhaps, the myriad telegraph wires that threaten the devoted neck of the passenger might be carried underground. Of course nothing will be done at present, as not even an omnibus horse was injured by the wires that, in some instances, hung across the streets. When some one in the Post Office is strangled or beheaded, the Post Office authorities will, perhaps, consider the matter."

Messrs. Beal, Son, and Chartres write to the *Daily News* as follows :—"We had so narrow an escape of our lives here yesterday (6th inst.) that it is as well to record it as a protest against overhead wires. A large skylight covers one of our offices, and owing to the breaking of the connection of the trunk wires portions of the parapet of the adjoining house were hurled through the skylight of a weight sufficient to have killed anyone seated therein. No one for the instant was in the room, but the chairs in which they would have been seated bear evidence of the force at which the stone and brickwork descended. The company have acknowledged their liability, but the moral we venture to draw is 'No more overhead wires.'"

A great number of narrow escapes from falling wires have been reported ; but although much damage to property has been done the only serious cases of personal injuries appear to be that of the man in Clerkenwell, whose eye was entered by the broken point of a wire, and another man at Peckham, who was seriously hurt by the fall of a telephone pole. Most of the breakages occurred in early morning, before street traffic commenced, and to this cause undoubtedly we may attribute the remarkable fewness of personal casualties.

MAGNETISM.

BY WILLOUGHBY SMITH.

(Concluded from page 178.)

Figs. 1, 2, and 3, in Diagram VIII., show the results obtained with a rod, square plate, and a disc of iron. The arrows indicate the

DIAGRAM VIII.

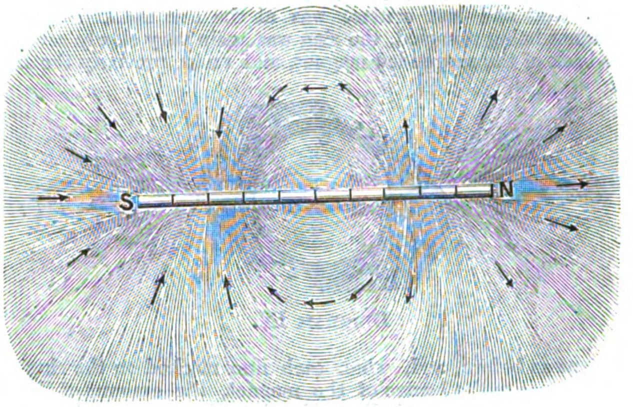

FIG. 1.

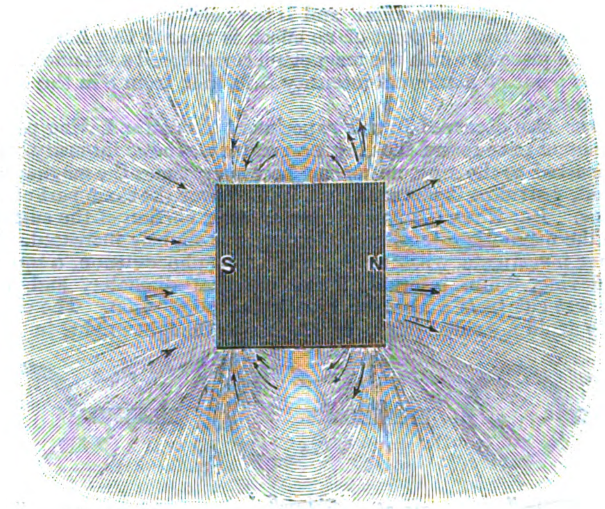

FIG. 2.

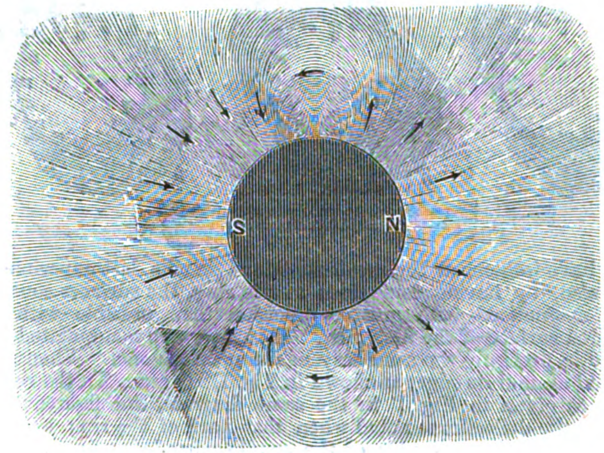

FIG. 3.

direction assumed by the magnet in each position in which it was placed relatively to the iron, which in each case remained stationary. The results are very similar to those obtained by the single mirror reflecting magnet ; and, as that arrangement was more easy

of manipulation and accurate in measurement, it was again used for all similar experiments.

If permanent polarity, however slight, has been communicated to either iron or steel in any form by any known means, the intensity and direction of its polarised lines of force can be measured. A ring made from a steel rod ·375in. diameter was hardened in oil and then mounted on a wooden disc, through the centre of which passed a small spindle, to allow of the ring being easily revolved vertically at right angles to the small suspended magnet, the distance between the two being 18in. No effect was observable on the magnet, although the ring was revolved several times. The outer surface of the ring was marked off into eight equal parts. One of these lines was marked S, and magnetism was then imparted to the ring as follows. The south pole of a powerful permanent steel bar magnet was placed on that part of the ring marked S, and the ring was then slowly revolved until its circumference had passed *once* under the south pole of the magnet, so that the point of first and last contact was at the line marked S. The bar magnet being removed, the ring was again very slowly revolved at the back of the suspended magnet, and under precisely the same

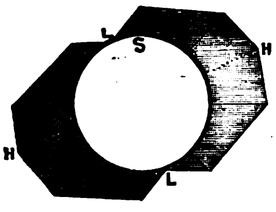

DIAGRAM IX.

conditions as before, and, when each line marked on the ring was directly opposite the centre of the magnet, the amount of the deflection of the magnet, as indicated by the reflection from the mirror, was noted. Diagram XI. shows the results obtained ; H indicates the position of greatest effest, and L the position of no effect. It will be seen that the point of no effect is near to the line S, that being the place at which the magnetism commenced and ended ; and that the point of maximum intensity is farther from S in the opposite direction.

It was also observed in this experiment that after having passed the magnet once round the ring, no greater magnetic intensity could be imparted to the ring, no matter how many times the magnet was applied, providing it was each time applied over the same part of the surface. But if it were passed over another portion of the surface, then the magnetic intensity of the ring was slightly increased. To further investigate what to me was a new phenomenon, a square-edged ring, 8·5in. internal, 9·5in. external diameter, and ·5in. thick was cut from a plate of best "Lowmoor" iron. The object was to avoid a welded joint, which it was thought might, in some

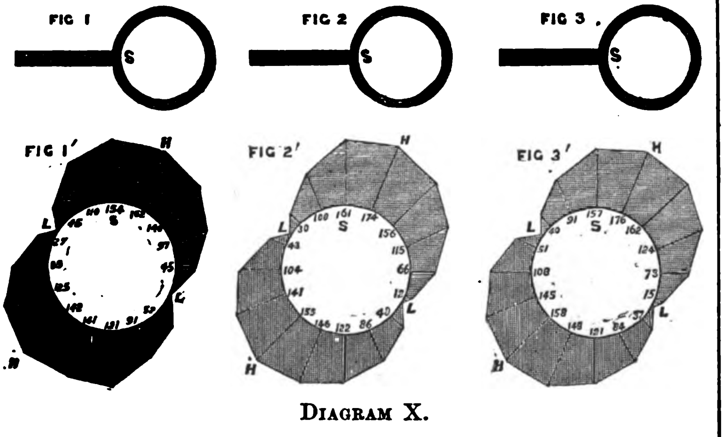

DIAGRAM X.

way, have influenced the results obtained in the last experiment ; and also, by having four sides to the ring, the surfaces could be each magnetised with greater precision than possible with the rounded surface of the first ring. This ring was manipulated and tested in precisely the same way as the previous one. When magnetised around its edge, as shown in Fig. I, Diagram X., the results were as given in Fig. I′ in the same diagram, the figures representing the deflections noted when that part of the ring was in a direct line with the centre of the small suspended magnet. Figs. 2 and 2′ show the results after the magnet had also been applied to the top side of the ring, and Figs. 3 and 3′ after the magnet had been passed over its under side. Looking at the total of all the deflections of each test it will be seen that the increase of intensity is very small for the additional application of the magnet on either of its sides. These experiments were continued with a steel bar in the place of the ring, and it was found that if the bar were magnetised by drawing the magnet from end to end, as in Fig. 1, Diagram XI., then the maximum result is obtained by the first rub, unless a fresh surface of the bar passes under the magnet ; but if the magnet be passed from the middle of the bar to one end, and the magnet being then reversed, it be passed from the same point of the centre of the bar to the other end, as in Figs. 2 and 3, then the induced magnetism in the bar is increased by repeated applications of the magnet. In one experiment the following values were obtained :—

After one rub, deflection	137
,, five rubs, ,, ...	156
,, ten rubs, ,, ...	176
,, fifteen rubs, ,, ...	180

Although the magnetism induced into the bar is only increased by repeated application from 137 to 180, or 31 per cent. as measured by the energy of its polarised lines of force, yet its attractive power is nearly doubled, as the attraction between a magnet and its armature increases as the square of its "free magnetism." In drawing the magnet along the bar from end to end, as shown in Fig. 1, it was observed that the ends of the bar were not of the same intensity, the end B, where the magnet leaves the bar, being considerably stronger than the point A, where the contact was first made.

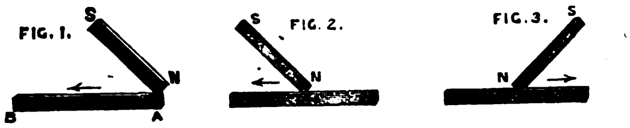

DIAGRAM XI.

It is just 100 years ago since it was first asserted that if an iron wire, not less than ten yards in length, were stretched in the open air, it would spontaneously give forth a sound when under the influence of a certain variation of the state of the atmosphere. On investigation, this was attributed to the effect of atmospheric electricity, and the correctness of that supposition was confirmed when it was demonstrated that the discharge from a Leyden jar through an iron wire produced the same phenomenon ; but no further notice appears to have been taken of the subject until 1837, when attention was called to the fact that if a flat spiral through which a current of electricity is passing, be brought near the pole of a powerful magnet, a sound would be heard. In the following year it was made known that if a soft iron armature be revolved rapidly before the poles of a horse-shoe magnet, a sound is produced, and in 1843 it was noticed that plates or rods of iron, when placed in the interior of a helix, gave a very decided sound each time the helix was connected with, or disconnected from, a strong electrical battery ; it being also, at the same time, asserted that a decided elongation of the iron rod occurred simultaneously with the sound. These phenomena were attributed to a change, produced by the magnetism, in the molecular constitution of the magnetised iron. The sound can be distinctly heard without external aid, but the

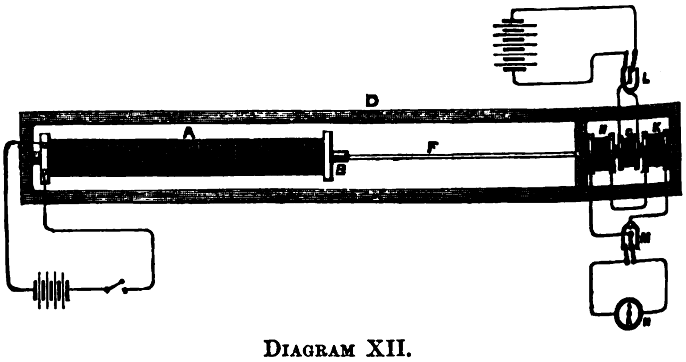

DIAGRAM XII.

supposed elongation of the rod requires very delicate appliances for measuring it, as under the most favourable conditions it is very minute. Prof. Joule, in one of his experiments, found that a bar of soft iron experienced a "decided elongation," which was about $\frac{1}{720000}$ of its total length, at the moment when the current by which it was magnetised was established, and a shortening at the moment when it was interrupted. These phenomena have frequently engaged the attention of experimenters, but no definite or satisfactory results have, as far as I am aware, been arrived at.

It has recently been experimentally demonstrated that a rod of iron only increases in length up to a certain point, and that if the strength of the exciting current passing through the helix be increased after the maximum length is reached contraction commences, and the bar apparently becomes shorter than its

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original length. In my research in this direction, great difficulty was at first experienced from the want of a simple, but at the same time, efficient measuring apparatus; this was at last overcome by the construction and adoption of the apparatus as shown in Diagram XII; this arrangement proved most valuable, not only for these experiments for measuring the expansion and contraction of metals under the effects of varying temperatures, and other similar experiments; in fact, as a gauge it can be made as accurate and sensitive as "Newton's scale of colours."

A, is a helix of cotton covered wire (·083" diameter) wound in ten layers of 198 turns each, the resistance of the entire length being 1·613 ohm. Inserted in the helix is the iron bar B, 1·375 inches diameter and 27 inches in length; one end is rigidly fixed to the wooden frame D, and the other end carries a glass rod F, the further end of which passes freely through the hollow iron core of bobbin H and supports the centre bobbin of wire with hollow iron core, G. A fine screw adjustment permits this bobbin to have a movement of about half an inch along the glass rod, so that it can be placed in any desired position between the similar bobbins H and K, which are rigidly fixed to the wooden frame D. A rapidly alternating current can be sent through the wire on bobbin G by means of a reverser, L. The wire on bobbins H and K is so joined that the electromotive force induced therein from G exactly neutralises each when the bobbin G is placed midway between them, but under these conditions the slightest movement of G is sufficient to destroy this neutrality. In circuit with the wire on H and K is a reverser, M, which causes the induced current to pass in one direction through the mirror reflecting galvanometer N. The glass rod was of sufficient length to allow H to be 31in. from the iron rod B, and at that distance no direct inductive effect from B apparently affected H. Having established the point of no current by shifting G until its neutral position was found, which was exactly midway between coils H and K, then, by means of the fine screw, G was moved $\frac{1}{3000}$th part of an inch from its central position towards K. This slight movement was sufficient to produce a deflection of 44·1 divisions on the galvanometer scale. Having obtained this "constant," the values given in Table II. were obtained. It will be seen on referring to the table that the apparent elongation of the rod has reached its maximum when a current of four amperes is flowing in the helix, and, as the current increases, an apparent contraction of the bar takes place until, with a current of 16 amperes, the rod appears to be of the same length as at the commencement of the experiment, and as the current is further increased, the length appears to diminish, and with 21·5

TABLE II.

Coefficient of Instrument:—

44·1 divisions on galvanometer scale = ·000333 of an inch.

Amperes flowing in Magnetising helix.	Deflection on Galvanometer.	Apparent increase in length.
1	1	·0000076 in.
2	4	·0000302 ,,
3	8·5	·0000642 ,,
4	9	·0000680 ,,
5	9	·0000680 ,,
6	8·5	·0000642 ,,
7	7·5	·0000567 ,,
8	7	·0000529 ,,
9	6	·0000453 ,,
10	5	·0000378 ,,
12	3·5	·0000264 ,,
14	1	·0000076 ,,
16	0	——— ,,
18	− 2	− ·0000151 ,,
20	− 3·5	− ·0000264 ,,
21·5	− 6	− ·0000453 ,,

amperes, it appears to be ·0000453 of an inch less than its original length. I have said *apparent* elongation and contraction of the rod, and I have intentionally done so, for it is my belief that neither elongation nor contraction takes place. I have already stated that if a helix of insulated copper wire be placed horizontally, and one end of a rod of soft iron be presented at one end of the helix, it will be attracted into the helix on the first impulse of the current, and place itself so that its centre coincides with that of the helix. And also that a helix of insulated wire, enclosing an iron core, not only causes the iron to become and continue a magnet by induction so long a current is flowing through the helix, but that the helix itself becomes a magnet, and possesses a sphere of magnetic lines of force quite independent of similar lines given out by the iron. This being so, it appears to me that, as soon as the current is passed into the helix, the lines of force from the rod endeavour to place themselves symmetrically with those given out by the helix, and thus, I think, is caused the slight movement of the whole rod, and not an elongation of it as supposed. When the rod becomes saturated, the intensity of its lines of force remain constant; but not so with those from the helix, as they continue to increase in intensity in proportion with the increase of the tension of the current passing through the circuit, and thus, I think, affect the lines of force of the rod, causing the latter to move in the opposite direction, which movement is mistaken for contraction. Just as I have shown the small magnet is moved by its lines of force adjusting themselves so as to be symmetrical with the lines proceeding from the iron rod or disc, so, I believe, is the iron rod moved by its lines of force adjusting themselves to those of the helix, and, I further believe, that the sound usually heard on making or breaking the current, in an experiment of this kind, is not due, as is supposed, to any effect in the iron itself, bat is caused by the lines of force adjusting themselves to each other; for, as is well known, the more intense the current the louder the sound, as instanced in the sounds given off by what is termed the "discharge" from powerful electrical machines, or that produced by an electrical phenomenon of nature which produces the sound called thunder.

Although far from having exhausted the subject—in fact, it appears to me inexhaustible—I feel that sufficient, if not more than sufficient, has been written to accomplish the purpose with which this pamphlet was commenced. I will therefore conclude by remarking that, what I have written being intended for instruction and not display, I have avoided all those phrases and technicalities which are so apt to puzzle and mislead, and have endeavoured to express my meaning in plain and simple words.

LEGAL.

The London and Provincial Winding Up.

In the Chancery Division of the High Court of Justice on Tuesday, before Mr. Justice Chitty, Mr. INCE, Q.C. (with whom was Mr. RIBTON), made an application on behalf of the solicitor to the liquidator of the London and Provincial Electric, &c., Company (Limited), under these circumstances:—In October the learned judge decided that the name of Mr. Geminari should be removed from the list of the contributories to this company. The same question now arose in regard to the names of three other gentlemen—Mr. Hall, Mr. Maitland, and Mr. Marposo. The understanding was that Mr. Geminari's should be a test case; but that was, as stated in the affidavits, "on the assumption that there are no facts relative to his case which are not applicable to the cases of the other parties." But there were distinguishing facts which made the cases not alike, and under these circumstances the liquidator desired the directon of the Court.

Mr. MAIDLOW, on the other side, contended that the question was asked whether the circumstances of the two cases were exactly the same, and to that no answer was given. The matter proceeded, and now, after the facts had gone against the company, the misrepresentations being found to be too flagrant to be passed over, they wanted to go behind the arrangement. The applicants in question had succeeded in the essence of the case between the parties. On the facts, the cases of the three gentlemen were even stronger than was that of Mr. Geminari.

The JUDGE said the point that there was a difference between the two cases was not raised until Geminari's case had been decided. The correspondence was not business-like; but he thought he should be going too far if he said that it was not open to the parties, even after that decision, to say that the facts of the cases were not the same. He had reluctantly come to this conclusion. Mr. Maidlow had come very near to establishing the fact that the agreement to make Geminari's a test case was concluded, but he had just fallen short of doing that. The case of the other three applicants would have to be heard.

COMPANIES' REPORTS.

Eastern Telegraph Company (Limited).

Report and accounts of the Directors for the half year ended 30th September last, to be presented to the twenty-seventh half-yearly ordinary general meeting, to be held at the Cannon-street Hotel, on the 21st inst., at one o'clock:—

The revenue for the period amounted to £331,419. 19s. 6d., from which are deducted £86,935. 11s. 10d. for the ordinary expenses, and £45,288. 17s. 3d. for expenditure relating to repairs and renewals and laying of cables, &c., during the half year. After providing £6,189. 13s. 4d. for income-tax, there remains a balance of £193,005. 17s. 1d., to which is added £1,101. 3s. 2d. brought from the preceding half-year, making a total available balance of £194,107. 0s. 3d. From this balance there has been paid—

	£	s.	d.
Interest on Debentures and Debenture Stock......	£27,260	10	6
Dividend on Preference Shares	20,296	17	4
Two Interim Dividends of 1¼ per cent. each on Ordinary Shares, with bonus of 1s. per share (¼ per cent.)	114,000	0	0
	£161,557	7	10

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Leaving a balance of £32,649. 12s. 5d., which is carried forward to next account. The revenue includes £13,650 dividend for the half year upon the Company's shares in the Eastern and South African Telegraph Company, being at the rate of 7 per cent. per annum, and also £2,794. 10s. 9d. net receipts for the half year on the shares of the Black Sea Telegraph Company belonging to this Company. The several sections of the Company's cables and the land lines in connection therewith continue in good working order. The duplicate cable of the Eastern and South African Telegraph Company between Zanzibar and Mozambique, referred to in the last report, was successfully laid and opened for traffic in August last. All the cables belonging to that company are in good working order. The new twin screw steamship "Mirror," mentioned in the last report, was succesfully launched on the 21st December last by the builders, Messrs. R. Napier and Sons, Glasgow. The ship will be completed and ready for sea early in this year.

In August last an International Telegraph Conference was held in Berlin, to which the English companies were invited to send representatives. Important questions were discussed affecting the interests of the companies, and a proposal urged by the Indian Government to reduce the rate between England and India was agreed to. Important reductions in the European tariffs were also voted by the Conference. It is estimated that these alterations will affect the Company's revenue to the extent of £40,000 a year, but the Directors trust that with the growth of traffic resulting from reduced rates the loss will be gradually diminished.

Her Majesty's Government having invited tenders for establishing submarine telegraphic communication between St. Vincent (Cape de Verde) and the British possessions on the West Coast of Africa, this Company and the Brazilian Submarine Telegraph Company joined in sending proposals, which have been accepted, under which a subsidy of £19,000 a year for twenty years is granted by the Government in respect of a cable from St. Vincent to Bathurst, Sierra Leone, and other British possessions southward to the mouth of the Niger. A separate company, called the African Direct Telegraph Company, has been formed to carry out this project, and the Directors, with a view to the additional traffic which will be brought over this Company's lines, and the strengthening of its interests in Africa, have agreed, subject to the approval of the shareholders, to provide one-third of the capital required. As the larger part of such capital will be raised by debentures of the African Direct Company, it is estimated that this Company's proportion of the balance to be issued in shares will not exceed £75,000, which the Directors propose should be subscribed and paid for by the issue of a sufficient amount of this Company's Four per Cent. Debenture Stock, which is now at or above par. The arrangements with the Governments concerned are not yet completed, but further explanations on the subject will be given at the meeting.

In accordance with the provisions of the Articles of Association, two of the directors, Lord Sackville A. Cecil and Lord Alfred Paget, retire by rotation at this meeting, and, being eligible, offer themselves for re-election. The auditors, Mr. Henry Dever, and Messrs. Quilter, Ball, and Co., retire, and offer themselves for re-election.

Direct United States Cable Company (Limited).

Report of the Directors for the six months ended 31st December last to be presented at the seventeenth ordinary general meeting of the Company, at the Cannon-street Hotel, on Friday, the 22nd inst., at 2 p.m.:—

For the half-year the revenue, after deducting out-payments, amounted to £38,115. 3s. 5d., against £68,824. 5s. 2d. (after similar deductions) for the corresponding half-year of 1884, being a difference of £30,709. 1s. 9d., against the half-year under review, owing to the operation of reduced tariff and competition. The working and other expenses for the same period, including income-tax, &c., but exclusive of cost of repairs of cables, amounted to £16,631. 13s., leaving a balance of £21,483. 10s. 5d. as the net profit of the half-year, making, with £10,733. 14s. 7d. brought forward from the previous half-year, a total balance of £32,217. 5s. For the corresponding half-year of 1884 the working expenses and other payments, exclusive of debenture interest, amounted to £16,857. 15s. Interim dividends of ¾ per cent. each, for the quarter ending 30th September, 1885, paid 24th October, 1885, and for the quarter ending 31st December, 1885, payable 23rd January, 1886, together amounting to £18,213, have been declared. The sum of £8,037. 3s. 9d. has been set aside to the reserve fund, thereby increasing that fund to £320,000, leaving a balance on the revenue account of £5,967. 1s. 3d., which has been carried forward. The interruption in the short section of cable mentioned in the last report was repaired on the 27th August. A break occurred in the main section on the 4th September last and was promptly repaired on the 7th of the same month. The cost of the above repairs, £3,362. 12s., has been charged against the reserve fund. With a view of affording additional facilities to the public joint offices have been established by the associated companies at Glasgow, Bristol and Havre.

Western and Brazilian Telegraph Company.

Report of the Directors, to be presented at the thirteenth ordinary general meeting of the Company at the Cannon-street Hotel, on January 21, at 12:30 p.m.:—

The total earnings amount to £127,396. 9s. 5d., an increase of £21,222 1s. 1d. compared with last year. The working expenses for the year, exclusive of renewals of cable, amount to £60,155. 19s. 4d., as against £61,871. 5s. 2d., a decrease of £1,715. 5s. 10d. The Company has had to replace by sheathed cable during the year 156 miles of the old unsuitable type of cable; the amount thus expended, £15,175. 10s. 6d., has been charged to the renewal fund. Including the amount brought forward from 1884, the balance to the credit of the revenue account is £42,296 17s. 9d., of which £10,000 has been placed to the renewal fund, leaving £32,296. 17s. 9d., from which the Directors recommend the payment of a dividend of 2¾ per cent. free of income tax, leaving £3,459. 0s. 3d. to be carried forward. This will give to the Preferred Ordinary shares 5 per cent. for the year and ½ per cent. on account of the year ending 30th September, 1884. The Directors would have been enabled to recommend the payment of a larger dividend to the shareholders, but for the loss on exchange, which has continued to increase, and amounted during the year to £10,648. 6s. 3d. In order to place the system between Pernambuco and Rio de Janeiro in perfect order, by the immediate removal of the remaining old strand type, which had become faulty, the Directors invited tenders for the manufacture of 200 miles of sheathed cable. The Company's ss. "Norseman" was ordered home to carry this cable to Brazil, and has now arrived out on the coast. During her absence the duty was provided for by placing the "Viking" in the centre of the system to be ready for any emergency. The Directors again draw attention to the extensive renewal of the old strand type of cable during the year; the steps now taken will complete the removal of this faulty type from the main revenue earning sections of the Company. Owing to pressing competition, efficient and speedy repairs have been absolutely necessary in order to keep the traffic over the Company's line. The remaining mileage of the strand type will now be reduced to 226 miles between Ceara and Pernambuco, and there is therefore a near prospect of reducing the heavy expenses caused by the maintenance of repairing ships, by rearrangements rendered practicable owing to the permanent improvement effected in the Company's system. It may be as well to remind the shareholders that, under many difficulties, no less than about 2,300 miles of solid sheathed cable have been substituted for the old unsuitable strand type. The retiring Directors are Mr. Andrews and Mr. Goodsall, who offer themselves for re-election. The auditor, Mr. Weise, retires, and is eligible for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Jan. 13.		Business Done Week Ending Jan. 13. Highest.	Lowest.
Anglo-American	33,	34	33	31½
Do. Preferred	56,	57	56¾	53½
Do. Deferred	10,	11	10⅜	9¾
Brazilian Submarine	10⅝,	10⅞	10 13-16	10½
Cuba	10¾,	11¼	11¼	10¾
Do. Preference	17½,	18½	18¼	18⅛
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9¼,	9½	9 15-16	9 3-16
Eastern Telegraph	11¾,	12	11 15-16	11
Do. 6 per Cent. Preference	13¾,	14	14	—
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	12⅞,	13⅛	13 1-16	12⅞
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 3-16	7
Do. Preference	13⅝,	13⅞	13 13-16	13 9-16
Great Northern	14¼,	14¾	14⅝	14⅜
Indo-European	32½,	33½	32¾	32¼
Reuter's	7,	7½	—	—
Submarine	200,	210	207	—
West India and Panama	⅝,	⅞	—	—
Do. 1st Preference	8¼,	8¾	8⅝	8 5-16
Western Brazilian	6⅜,	6⅞	6¼	6⅝
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	15-16,	1 1-16	1	15-16
Oriental	3-16,	5-16	—	—
United Telephone	12¼,	12¾	12⅝	12 1-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3¼,	3⅝	3¾	3 5-16
Do (fully paid)	5¼,	5½	5½	5½
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1¼,	1½	1 7-16	1½
Maxim-Weston	¼,	¾	5-16	—

MISCELLANEOUS.

Telegraph Construction	36½	37½	37¼	36½
India Rubber, Gutta Percha, and Telegraph Works	24,	25	25½	24½

TRAFFIC RECEIPTS FOR DECEMBER, 1885.

Companies.	Dec., 1885.	Dec., 1884.	Increase.	Decrease.
Cuba Submarine	2,450	2,553	—	103
Direct Spanish Telegraph	1,754	1,748	6	—
Eastern Extension	34,785	41,426	—	6,641
Eastern Telegraph	53,179	53,036	143	—
Great Northern	20,280	—	—	—
West Coast of America	3,825	—	—	—

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NOTES.

THE TASMANIAN DUPLICATE CABLE.—The duplicate cable between Victoria and Tasmania has been completed.

THE ELECTRIC LIGHT OF ASIA.—The King's palace in Corea is now lighted with electricity of the Yankee brand.

OBITUARY.—Captain E. C. Armstrong, an electrician of Cincinnati, died 29th December, in that city, of consumption.

NOT ALWAYS REMEMBERED.—Faraday proved the magnetic condition of matter, and that magnetism, unlike electricity, cannot be insulated.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 15th inst. amounted to £3,147.

THE EASTERN CRISIS.—A telegram from Philippopolis, dated 19th inst., announces that telegraphic communication with Constantinople has been re-opened.

UNDERGROUND WIRES IN PHILADELPHIA, U.S.A.—The City Councils of Philadelphia have decided to confer with the companies interested before beginning wire-cutting.

ELECTRIC LIGHTING AT HANLEY.—The Hanley Corporation have appointed a Committee to report on the desirability of lighting the town and public buildings with the electric light.

THE AMERICAN TELEGRAPHS.—It is stated that during the year the amount of press telegrams sent over the lines of the Western Union Telegraph Company alone was over a thousand million words.

THE TELEPHONE IN BOSTON, U.S.A.—Advices from Boston state that the net output of the Bell Telephone Company for the month ended December 20th was 1,597, against 379 in the month previous.

ON ACCUMULATORS.—M. Dieudonné has been invited by the Committee of the Neuilly Polytechnic Association to read a paper on electric accumulators and their practical application to existing industries.

THE SHEFFIELD TECHNICAL SCHOOL.—The new Technical School at Sheffield, which has just been established in connection with Firth College, will be formally opened on the 1st February by Sir Frederick Bramwell.

THE ELECTRIC LIGHT FOR WAR-SHIPS.—The Admiralty have ordered that in future all large ironclads belonging to Her Majesty's Navy are to be furnished with not less than four electric search lights and mirrors.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th January are £2,685, as compared with £2,624 in the corresponding period of 1885.

VOLCANIC ERUPTION.—Intelligence has been received at New York that an eruption of the volcano Colimba (? Colima) commenced on the morning of the 15th inst., when stones of an enormous size were ejected from the crater to a great height.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 15th inst. were £2,429, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

AN ANNUAL DINNER.—By permission of the Major-General commanding the Home District, the annual dinner (revived) of the non-commissioned officers 2nd Division Telegraph Battalion will take place at the Masons' Hall Tavern, Basinghall-street, E.C., on the 5th February, at 6:30 p.m.

THE CUBA SUBMARINE TELEGRAPH COMPANY. — The directors of this company have resolved, after providing for the dividend on the preference shares, to recommend the payment of a dividend on the ordinary shares at the rate of 7 per cent. per annum, free of income-tax, leaving £41 to be carried forward.

THE INDIAN EXHIBITION.—It is reported that the contracts for lighting next year's Indian and Colonial Exhibition at South Kensington have been arranged exclusively with the Anglo-American Brush Company, the Pilsen-Joel Company, and Messrs. Crompton. The lamps employed will be the Swan Company's incandescent lights.

THE NAVY.—The Admiralty have decided that the ships of our navy shall be exercised in night firing, and they have issued an order to the effect that once every half-year target practice shall be carried on at night. Vessels fitted with the electric light will make such use of it as the commanders think will best assist the accuracy of the firing.

SOCIETY OF ARTS.—Among the papers for which the dates are to be hereafter announced by this society, we notice "Domestic Electric Lighting," by W. H. Preece, F.R.S. On the 28th inst., Mr. Wm. Bottomley, jun., will read a paper on "Magnetism of Ships and the Mariner's Compass." The second course of the Cantor lectures will be upon "Friction," by Prof. H. S. Hele Shaw.

A NEW INSULATOR.—A new form of telegraph insulator has been patented by Mr. Benjamin N. Deblieux, of Bay St. Louis, Miss. It consists of two longitudinal sections placed together to form a joint in the middle and retaining the wire between them, the sections being clamped together, and so supporting the line wire without wrapping or cutting, and altogether obviating a tie wire.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—The first meeting of this society for the present session will take place on the 28th instant at the Institute of Civil Engineers, when the President, Prof. D. E. Hughes, F.R.S., will deliver an inaugural address, consisting of an account of his researches on "Self-induction of an Electric Current in relation to the Nature and Form of its Conductor."

LIGHT ON THE HIRE SYSTEM.—We have been favoured by the Anglo-American Brush Electric Light Corporation with a memorandum as to the hire of apparatus for electric lighting upon the purchase hire system. This Corporation, it appears, are now prepared to supply on hire dynamos, lamps, and all accessories for lighting, and to install the apparatus, the sums paid by way of rental being allowed for in the event of purchase.

COMMUNICATION WITH THE CONTINENT.—The *Daily Telegraph* understands that the Postmaster-General has consented to receive a deputation from Liverpool respecting a proposal to establish direct telegraphic communication between that city and the Continent. The necessity of this is stated to be the insufficiency of the present cables to transmit, with due speed, the messages despatched after the opening of the principal commercial and financial markets.

PERSONAL.—At the annual meeting of the Northern District Telephone Company, held in December, Mr. Clay, who has been well known in connection with the United Telephone Company for some years, was appointed manager of the

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company, a position he has practically held for the past six months. The appointment of one so well known in the telephone world will, doubtless, be a subject of congratulation to the Directors and *employés* of the company.

Earthquake Shocks in Central America.—A telegram from Panama states that intelligence has reached there that the town of Amatitlan in Guatemala was nearly destroyed by an earthquake on the 18th December last. There were altogether 131 shocks, but no fatal results are reported. Shocks of earthquake have also occurred in other parts of Central America, and volcanic rumblings are reported from Ecuador, produced, it is supposed, by an eruption of Cotopaxi.

Synchronised Clocks.—The Estates Committee of the Birmingham Town Council proposes to establish a system of public clocks in the town. There are to be twenty clocks, erected in conspicuous places—at the intersection of streets by preference—and these clocks are to be controlled by electricity, so as to keep accurate time, and are to be illuminated at night. The estimated cost is £2,500 for the establishment of the clocks, and £200 a year for their maintenance.

The Electric Light on the Thames.—At the last fortnightly meeting of the Managers of the Metropolitan Asylums Board the report of the Hospital Ships Committee was brought up, in which they submitted an agreement to be entered into between the managers and the Commissioners of Sewers for Dartford for laying the cable for the electric light through the river bank at Long Reach, recommending that the common seal of the managers be affixed thereto, which was agreed to.

The Late M. Paul Baudry.—It is stated from Paris that the friends and admirers of the late M. Paul Baudry are arranging to get up an exhibition of his drawings, portraits, and minor paintings, but the work of works being the ceiling of the Opera House saloon, it is agreed that the room is to be thrown open to the public on Wednesdays and Thursdays from noon to midnight. As in the monumental apartment gas has been superseded by the electric light, this can be done at a small expense.

A Little Knowledge.—Our contemporary, *L'Electricien*, says that an amateur gravely asked, the other day, with what liquid the Gaulard-Gibbs secondary generators acted; and another gentleman, whose knowledge of electrical science was somewhat exceeded by his ambition, was desirous of achieving immortal fame by coupling up a dynamo with an electrostatic induction machine in order that due advantage might be taken of the large quantity of the current furnished by the one, and the enormous tension of the other.

A Humane Proposal.—Some degree of interest will be excited by the fact that Baron Leon de Lenval, of Nice, has offered a prize of 3,000f. for the best and most convenient adaptation of the microphone for the improvement of hearing in cases of partial deafness. The award committee will receive apparatus intended for competition up to the 31st of December, 1887, and the awarding of the prize will take place at the Fourth International Conference for Otology, which will be held at Brussels in September, 1888.

Taunton.—It is said that after a month's trial of the Thompson-Houston system of electric arc lighting at Taunton, the principal tradesmen met recently to consider the advisability of establishing a limited liability company to supply the light. Mr. Wharton explained the system; and Mr. Massingham, of Bath and Taunton (who was mainly instrumental in introducing the light into the town) said each arc lamp of 1,200 candle-power would, on an average, cost £15 a year. He estimated the capital required at about £5,000, which would, he said, erect machinery to supply 120 arc lights. A resolution in favour of adopting the light was carried unanimously.

A Submarine Volcano.—Information has been received at the Admiralty from the United States Government that the captain of the steam vessel "Janet Nicholl" reports the submarine volcano southward of Culebras Reef as having become active, and formed an island about two miles long in a north and south direction, and about 250ft. in height. A reef extends off the southern end of the island for a distance of a mile and half, and off the northern end for half a mile. Approximate position as given, lat. 20 28 S., long. 175 21 W. The position above given is thought to agree closely with that of the submarine volcano reported in 1877, about six miles northward of Honga-Tonga island.

Academie des Sciences.—At the general meeting, which was held at the 21st ult., the Bordin prize was awarded by the Academie to M. Edlund, Professor of Physics at the Royal Academy of Science, Sweden. The subject was that proposed for 1882, and revived for 1885, viz.:—"Researches upon the Origin of Atmospheric Electricity, and the Causes of the Excessive Development of Electric Phenomena in Storm Clouds." The subject proposed for 1884, which carries with it the mathematical prize, consisting of a medal of the value of 3,000f.—*i.e.*, "The Perfection in Each Important Point of the Application of Electricity to the Transmission of Work," is to be the subject for this year. The papers are to be forwarded to the secretary before the 1st of June next.

The Electric Light in Chicago.—M'Vicker's Theatre, Chicago, has adopted the arc light, to take the place of the calcium light, in lighting up scenery. The lamp used is a hand regulator with carbons 9·16in. in diameter. The chief peculiarity of the lamp, which is extremely simple, is a half cylinder of lime, which is hollowed out to enclose the arc. This lime acts as a reflector for the light, and itself becomes luminous, changing the quality of the light, so that the effect is nearly the same as that of the calcium light; in fact, without the use of the lime in this manner, the light could not be used for the purpose, as the lime steadies the light and decreases the danger of extinction. This theatre is lighted by the Edison system, which supplies the current for the arc light.

University of London.—A meeting of Convocation was held on Tuesday evening at the University Building, Burlington-gardens, Dr. Wood, chairman of Convocation, presiding. Mr. Carpenter, in the absence of Mr. R. H. Belcher, moved the reception of the report of the annual committee. This report gave as an appendix a long report, in much detail, presented by the sub-committee which had been appointed to consider the regulations of the matriculation examination. Briefly, the suggested amended syllabus omitted modern geography from the present subjects of examination, substituted mechanics for natural philosophy, and in place of chemistry gave one of the following branches of experimental science:—1. Chemistry. 2. Heat and light. 3. Magnetism and electricity.

The Electric Light in Mines.—Referring to the use of electricity for the lighting of mines, a writer in the *South Wales Daily News* calls attention to the fact that *The Times*, when commenting upon Sir F. Abel's inaugural address at the Society of Arts, in November last, dealing with this subject, maintained that "electricity is the one illuminating medium which can supply the light which miners want, without the flame which endangers them." The writer in the Welsh paper says "the fracture of a glass lamp, or the rupture of a con-

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ducting wire in a mine might be as much fraught with danger as the injury of a safety lamp or the lighting of a pipe." We are glad that this gentleman said *might*. There is an old story in which the usefulness of this word is set forth, together with the merits of the qualifying *if*! No doubt our readers will remember it.

EARTHQUAKE IN CORNWALL.—Another earthquake occurred in the West of England on Wednesday morning. At Bodmin the houses were so much shaken as to startle the inhabitants. At Mevagissey a long rumbling noise was heard. In some of the houses the creaking of beams and flooring resembled the straining of a ship in a rough sea. At St. Blazey the inhabitants were so shaken in bed that they arose in fright. Buildings swayed to and fro and tottered. The shock took place at half-past six, and lasted about six seconds. Persons at St. Austell were terrified by a deep, rumbling sound, which was described as terminating in a noise like that of an explosion in the distance. Houses were shaken, and china and glass were set jingling. Some persons describe the sound as being like that of two distinct explosions rapidly following each other, the latter being by far the louder. At Wheal Eliza Mine the shock was so great that the miners ceased work for a time, fearing that water had broken in.

OVERHEAD WIRES.—The following letter has been received by a gentleman who pointed out to the Postmaster-General that serious loss is incurred by the commercial community through the breakdown of telegraph wires by snowstorms, &c., and inquired whether the department contemplated an established system of underground wires, similar to those now in use in the German Empire:—"General Post Office, London, January 15. Sir: I am directed by the Postmaster-General to acknowledge the receipt of your letter of the 12th inst., and to inform you in reply that this department has already placed a very large number of wires underground in and around London and in and around the principal towns in the United Kingdom. More works of this kind will be carried out from time to time as opportunity offers, but the Postmaster-General cannot hold out a hope that the telegraph wires throughout the country will be placed underground.—Yours, &c., C. H. Patey."

TELEPHONY IN THE NORTH.—The Northern District Telephone Company are opening the new year in a very satisfactory manner, as regards work, and during 1886 it is intended to complete most of the trunk lines, several of which are in hand already. The line between Wingate Colliery and Hartlepool—a distance of 12 miles—was opened just before Christmas, and has proved a great success, which is highly satisfactory, as it constitutes a very important part of the trunk line between Sunderland and Hartlepool. Subscribers to the company's system in Sunderland have been enjoying a little theatre diversion made easy, as the Theatre Royal in Newcastle has been connected up. An ingenious subscriber has fixed up one of the large advertisement placards of the pantomime depicting all the scenes and characters, and says that with the aid of that and the telephone it is just as good as being in the theatre. It is satisfactory to hear that the company have not at all suffered from the trouble of broken wires during the winter.

THE INSTALLATION AT THE PALAIS ROYAL.—During the last two months Mr. Jehl, of the Paris Branch of the Edison Company, has been occupied with the installation at the Palais Royal. This is divided into three parts, *i.e.*, Le Palais Ancien Côté du Roi, 263 lamps; Le Palais Ancien Côté de la Reine, 203 lamps; Le Nouveau Palais, 883 lamps; or a total of 1,349 lamps in all. The Old Palace is being completely installed, but at the New Palace it is only intended to put in new sockets, lamps, switches, &c., and to alter the wiring done by the Brush Company so as to allow of single lamps being used in parallel circuit. About 180 lamps have already been fitted up in the Queen's private apartments in the Old Palace, and these are lighted every night, the current being conveyed through an overhead cable from the dynamos at the theatre, a distance of about 380 metres. An underground cable will, however, be laid as soon as the weather permits. In the dining and smoking rooms of the New Palace the full complement of 182 lamps has been put in. M. Jehl expects to complete his task in about two months' time.

ELECTRICAL CONDUCTIVITY OF AIR UNDER REDUCED PRESSURE.—Experiments, by T. Homén, on the relation of the conductivity of air to the pressure, have led to the opposed conclusions that an absolute vacuum is a perfect non-conductor, and a good conductor of electricity. In this paper, an elaborate series of experiments on the conductivity of air in discharge tubes under various degrees of pressure are described. The results show that the phenomena of conductivity of air under reduced pressure are of two kinds, the one, the particular resistance of the air, which is proportional to the distance between the electrodes, the other the actual resistance of the electrodes themselves. The former is independent of the diameter of the air column, and its increase is nearly proportional to the pressure, whilst the latter increases very quickly with decrease of pressure, and under low pressures reaches a point at which the resistance is such that electricity, even at the highest difference of potential, cannot overcome it. These results are not in accordance with the view that a vacuum is a good conductor of electricity.—*Ann. Phys. Chem.*

THE AMERICAN EXHIBITION.—The American Exhibition is to open with a big, big boom on the 2nd of May, 1887. Arrangements are being made to include a Press Pavilion, an Atlantic Cable Office, an Electrical Elevated Railway, and reproductions of the façades and interiors of remarkable hotels and public buildings. The lighting of the buildings and the illumination of the grounds, avenue, gardens, and fountains by electricity, are already having the most careful attention of the Council, and will in themselves constitute an especially interesting and attractive display. The Executive Council invite tenders from persons and firms desirous of making proposals for concessions, or permits to sell, at the forthcoming exhibition. Forms of tender may be obtained on application to the Secretary, 7, Poultry, London, E.C.; 32, Nassau-street, New York, and to the State Commissioners. Among other things these concessions are for an electric railway, lectures, and telephones. There will be seven entrances to the buildings and gardens, all of which will be brilliantly illuminated at night by the electric light.

BY HYDRAULIC POWER.—A pamphlet by Mr. A. T. Walker, M. Inst. C.E., on behalf of the promoters of a Bill for the formation of a Hydraulic Power Company for Leeds, has been issued. This power is said to be in effective operation both at home and abroad, and not only in connection with railway and dock works and other large undertakings, but in smaller quantities for the driving of machinery of limited power. It is contemplated that not more than 300 indicated horse-power shall at first be provided, with accumulators giving, when fully charged, an additional 400 indicated horse power. Is is intended among other things to supply people who have not sufficient work for a boiler of medium size; others whose work would be more economically done by hydraulic than by steam direct; to supply small consumers, enabling them to do by

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power work they now do by hand, thus cheapening production; to render offices at the top of high buildings quite as convenient and as valuable as those on the ground floor, by being able to take up passengers and goods safely and rapidly; and lastly, providing power to warehouses, offices, and banks, for driving dynamos wherewith to light by electricity.

AN INTERESTING INSTALLATION.—Park Hill, Streatham, the residence of H. Tate, Esq., has been lighted throughout with glow lamps by Goolden and Trotter. The installation consists of about 200 lights, the current being supplied by a Goolden-Trotter dynamo and accumulators, the motive power being an eight horse-power gas engine. The lamps are Woodhouse and Rawson 50-volts of various candle-power, and the installation has been for several months entirely in the charge of the butler, Mr. J. Codling, who states that it gives entire satisfaction, and with the exception of some leakage of acid from the accumulators, no trouble at all. The installation is peculiar and interesting as being the first example of the employment of the magnetic switch introduced by this firm, whereby the lamps are lighted and extinguished from both inside and outside the rooms, or from several points in the same room, so that it is never necessary to enter a dark room; a great saving in the leads is also effected, as they are not required to be brought down to the switch buttons, which bring the switch into action by means of a few Leclanché cells on an ordinary electric bell circuit, being in some instances fully 100ft. away from the switch.

SMALL INSTALLATIONS.—On December 24 Sir Archibald Campbell, Bart., M.P., of Blythswood, gave an entertainment in which a Christmas tree was lighted with 120 glow lamps of 20 candle-power. The current was supplied from a Goolden-Trotter dynamo and accumulators, and the tree was in every sense of the word a brilliant success. The lamps were Woodhouse and Rawson 42 volts. — At the bazaar in connection with the church and schools of Southowram, near Halifax, a large Christmas tree was lighted for three evenings with such good effect that no other lights were needed in the room in which the bazaar was held. The dynamo weighed only 1¼cwt., and the whole apparatus was sent over in a cab and set running the same afternoon off the one-half horse-power gas engine which is used for blowing the organ of Southowram Church. It appears that the clergy in the neighbourhood of Halifax take more interest in electric lighting than the manufacturers and millowners. Messrs. Goolden and Trotter lit the Church of St. John's in the Wilderness, Mytholmroyd, with three arcs inside and one on the tower, with a dynamo nearly half a mile off, for the harvest festival a few months ago, showing up the decorations with excellent effect.

MORE LITIGATION.—The United Telephone Company has served two writs upon Mr. W. H. Fleming, of Liverpool, for using the telephones of the New Telephone Company, comprising the "valve" transmitter and the "English mechanic" receiver. The former of these instruments, though it possesses no diaphragm, is alleged to infringe Edison's claim to the combination of a diaphragm or tympan with electric tension regulators; and the latter instrument, though its armature is borne upon a membrane, such as gold-beaters' skin, is alleged to infringe the Bell patent, in which such instruments are expressly disclaimed. Whether the monopoly company seriously thinks that it can prove the infringements of which it complains, may be doubted, as the New Company is known to be a very powerful association, with fighting capacities, and with ample funds for defending its rights. The entire body of electricians are interested in the issues involved; for, since the extraordinary failure of justice in the Bassano case (in which Mr. Justice North has never yet delivered his judgment, though the verdict was rendered many months ago), this is the first real attempt to decide whether a "disclaimer," such as that in the Bell patent, can be held to give the public any real protection.

DOMESTIC LIGHTING.—An extensive installation of domestic electric lighting has just been completed at Oakworth, Yorkshire, the seat of Mr. Isaac Holden, M.P. It comprises about 150 incandescent lamps; and a dynamo capable of supplying 100 incandescent lights of 20 candle-power each. There is a secondary battery of 110 cells in two sets of 55 in a little house in the garden, which is capable of maintaining 100 lamps for ten hours without recharging. The power for driving the dynamo is supplied by an 8 horse-power Crossley gas engine. The dynamo chamber and engine house is connected with Oakworth House by a large cable, which is laid to the butler's pantry, from which radiate all the minor cables for the various rooms. In the large reception rooms the splendid chandeliers formerly used for gas have been retained and adapted for carrying incandescent lamps, which are arranged in groups, screened by engraved and ground glass globes. In each room and hall there are also independent switches. The installation has been carried out by Messrs. Muir and Mavor, of Glasgow, who are contractors to the Government for the lighting of the Glasgow General Post Office, in which installation there are 400 incandescent lamps and 10 arc lights, most of which are running day and night.

AT THE SALPETRIERE.—At the Salpetriere Hospital, in Paris, electricity is one of the most important elements in the treatment of the sick. Its creation, in 1877, was due to the initiative of Prof. Charcot, and its organisation was the work of Dr. R. Vigoroux, who has continued to direct it ever since its foundation. The patients pass into the room for treatment, where most of them take a seat upon two rows of insulating stools, where they receive electricity from two machines in the middle of the room. They are thus in the first place submitted, for a length of time varying with the case, to an electric bath. Then the operator, provided with exciters, makes such an application to each person as the case requires. Those who are not to sit upon the stools go over to an electro-therapeutic table, where they receive electric applications of a different kind. The total number of persons treated at each sitting may be estimated at 200. The results of this electric treatment are said to be of the most satisfactory character. The electric machines are of the Carre system, but arranged horizontally. Dr. Vigouroux is now having others constructed on a new plan. The manner in which they are set in motion is as follows:—A Gramme motor located in the room actuates a shaft, on which there are distinct pulleys that receive two belts for the electric machines and one for a laboratory Gramme machine. The current is furnished by a dynamo situated about 600 yards off, alongside of the large steam engine of the laundry. This transmission of power was put in by Messrs. Breguet.

ELECTRIC LIGHT FOR STEAMSHIPS.—Not long ago several of the heads of departments of Messrs. Wilson, Sons, and Co. paid a visit to the steamer "Torpedo," in the Alexandra Dock, to witness the completion of many of the improvements which have been effected on this small but very beautiful addition to the Wilson line. Perhaps the most interesting feature on board this steamer is the electric lighting, which has been introduced all over the ship. The new system of lighting has been fitted on board by Mr. Muse, who has been most successful

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not only in producing a most perfect light, but in his distribution of the electric lamps. The engine room, where the final touches were being completed, was as light as day, whilst the saloon was rendered most brilliant. For working purposes, however, the side and masthead lights were the points of greatest interest to those connected with the ship, and here it would appear the greatest success had been attained. The masthead light had all the brilliance of a lighthouse on a small scale, and will be visible for a great distance, and the side lights were equally effective. The starboard or green light is always the weakest light on board a ship, and the most difficult to see from a distance, especially if the weather is not clear, but the "Torpedo's" green light showed out most perfectly, although during a great portion of the time it was exhibited rain was falling heavily. The "Torpedo" has been several voyages to and from Liverpool and Jersey, at which latter place she has been the object of very great interest. Messrs. Paterson and Cooper's machine is used on board, and gives great satisfaction.

LIGHTSHIPS AND TELEGRAPH STATIONS.—A very interesting and successful experiment was tried recently in Walney Channel with a model of Captain Moody's floating lightship and telegraph stations. The model was supposed to represent a floating lightship and telegraph station, with a hull 80ft. by 80ft., with a light 60ft. above the water line. The vessel is constructed with four equal rays or projections proceeding from a central circular deck protected by an iron bulwark from three to four feet high, and has many novel and useful features. She is moored by four strong cables running from the curvatures between the rays, and if the vessel is to be moored in mid ocean these cables will be attached to cylinders or buoys sunk to a certain depth, and from these again will be strong cables with anchors. If the vessel is placed in position anywhere near land four cables with as many anchors are required. The telegraph cable runs through a well in the centre of the vessel, and cannot by any possibility become twisted with the cable chains. The light is placed in an ordinary lighthouse lantern at the top of a lattice-work tower made of steel with ladders running up the inside. This tower is made pretty much in the same way as the three largest which carry the electric light on the Ramsden Dock, only it is much more substantial. On the occasion of the experiment the "station" was towed out into the channel and moored in very rough water. Great satisfaction was expressed with the trials. The model will next be sent to the Trinity Board, after which it will be sent to the Shipperies Exhibition, which is to be held at Liverpool.

THE PROPOSED NEW CABLE.—Some little time ago, says the *Colonies and India*, we mentioned that Her Majesty's Government had invited tenders for the laying, maintaining, and working a telegraph cable between Halifax (Nova Scotia), Bermuda, and Jamaica. The amount to be paid by way of subsidy was not stated, but some enterprising gentlemen in the City of London have had the matter under consideration, and the result is there has just been registered here "The International Cable Company (Limited)," with a capital of £1,000,000 in 100,000 shares of £10 each, the object of which is, as stated in the prospectus, to "establish, maintain, and work lines of telegraphic communication between the Azores, the West Indies, Canada and the United States, from such points on the coast of Great Britain and Ireland and the continent of Europe, or elsewhere, as the company may determine; also between any points on the coast of Canada, the West Indies, the Azores, the Bermudas, Central America and the South Pacific coast, and from the coast of Canada or America to Japan and the continent of Asia; to connect cables of the company with the Government internal telegraphic system of the Dominion of Canada, and procure from the Governor of Canada by letters patent under the Great Seal of Canada, or otherwise, a charter of incorporation upon such terms as may be expedient." The first subscribers, who take one share each, are Mr. George Gordon Leycester Macpherson, merchant; Mr. W. Pope, Mr. Ernest Heathfield, merchant; Mr. James Jacker, Mr. Thomas H. Craven, solicitor; Mr. Walter Galt Gibbon, accountant; and Mr. George Barrow Holroyd. The number of directors is to be not less than seven nor more than fifteen, and for their services the sum of £5,500 a year is to be divided amongst them. It will be remembered that in calling for tenders the Postmaster-General distinctly stated that Her Majesty's Government would have no liability or responsibility in respect of the cable beyond the payment of the subsidy, which may be for a term of twenty years, and will be payable at the end of each complete period of twelve months, provided that the cable has been maintained in good working order, and that a continuous service between the United Kingdom and Bermuda and the British possessions has been maintained. The communication must be established and in efficient working order within twelve months of the acceptance of the tender.

THE ELECTRICAL CONDITIONS OF THE HUMAN BODY.—The following is the syllabus of the Lumleian Lectures for 1886, by William H. Stone, M.A., F.R.C.P.:—Importance of placing the physiological and medical application of electricity on a physical basis of absolute measurement. Previous work done in this direction by Dubois Reymond, Count Du Moncel, and others, somewhat scanty. The human body exhibits: (I.) electrical resistance; (II.) electro-chemical capacity; and (III.) electrolysis. I. Resistance has been enormously over estimated owing to the high insulating power of the skin. This variable factor can be reduced to zero by obtaining perfect contact. Measurement of resistance by (*a*.) momentary contacts; (*b*) alternating currents; (*c*) Mance's second method. Errors involved in method *a*, by electrolysis, which sets up counter E.M.F. and in *b*, by electro-chemical or voltametric capacity. Resemblance of the human body to a faulty submarine cable. Mance's method *c*, intended originally for the latter, entirely removes these difficulties, and enables the three processes to be independently determined. II. Alternating induction currents as used in physiology have not been hitherto measured. The two momentary currents of Rumhkorf's coil of very unequal intensity. Helmholtz's correction. Superiority of a tuning fork commutator and battery in this respect. Methods of measuring alternating currents by (1) the dynamometer; (2) the quadrant electromometer. Estimation of the electrostatic capacity of the body by methods used in calibrating condensers. III. The amount of electrolysis produced by a constant current far larger than hitherto supposed. Accident to the Countess Du Moncel. Electric lighting accidents. Question whether the body behaves as a solid or a liquid conductor. Evidence that its resistance diminishes instead of increasing with heat. Great diminution of resistance on the occurrence of dropsical effusion. Physiological deductions from the above observations; traces of a mechanical law governing the length of the bones as levers, and the bulk of the muscles as powers. Great lessening of resistance in atrophied muscle, and in certain metallic impregnations. Predominant nervous action of rapid alterations of potential. Speculation as to the possibility of the human nervous system distantly resembling a duplexed telegraph cable, in which a transmitted impulse is balanced and inhibited at the sending station, but unbalanced and exhibited at the receiving station.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 188.)

The Mechanical Action between two Regions.

Summary of some results of Vector Analysis.—In order to keep the present section within limits, it will be desirable to first give a short summary of certain general relations, discussed at length in previous articles in this journal.

Let there be a distribution throughout space of a vector H, to be mentally realised by drawing lines following its direction, packing them closely where H is strong, loosely where it is weak. H may be the intensity of electric or magnetic force, the mechanical force on the unit of the corresponding matter. The field of H is decomposable into two fields of very different natures, say, $H = F + K$, such that F is a polar force, its line integral round any circuit being zero, and K has no divergence, or its lines are entirely closed. From this property it follows that ΣFK through all space is zero, making

$$\Sigma H^2 = \Sigma F^2 + \Sigma K^2.$$

The divergence of H is that of F only; the curl of H is that of K only. Let

$$\text{div.}H = 4\pi\rho, \qquad \text{curl.}H = 4\pi\Gamma; \quad . \quad . \quad . \quad . \quad (12a)$$

then ρ is the density of the "matter" of F, and Γ is the density of the "current" of K. (Say magnetic matter and electric current, or electric matter and negative magnetic current; but, so far as the present section is concerned, the matter and current are simply defined by (12*a*).) Let P and A be the potentials at any point, Q, of the matter and the current, according to

$$P = \Sigma\rho/r, \qquad A = \Sigma\Gamma/r, \quad . \quad . \quad . \quad . \quad . \quad (13a)$$

r being the distance from ρ or Γ to the point Q where P or A is reckoned. Then

$$F = -\nabla P, \qquad K = \text{curl.}A, \quad . \quad . \quad (14a)$$

show the derivation of F and K from the corresponding potentials. Also

$$F = -\Sigma\rho f, \qquad K = -\Sigma V\Gamma f, \quad . \quad . \quad (15a)$$

if f be the vector force at the place of ρ or Γ due to unit matter at Q, where F or K is reckoned. If we call the quantity $\Sigma H^2/8\pi$ the energy of H, the total energies of F and K are

$$\tfrac{1}{2}\Sigma F^2/4\pi = \tfrac{1}{2}\Sigma P\rho, \qquad \tfrac{1}{2}\Sigma K^2/4\pi = \tfrac{1}{2}\Sigma A\Gamma. \quad . \quad (16a)$$

The mechanical force per unit volume is

$$\rho H + V\Gamma H \quad . \quad . \quad . \quad . \quad . \quad . \quad (17a)$$

Limitation to a bounded region.—The above referring to all space, in order to apply the results to a bounded region we must suppose $H = 0$ outside it, for our temporary purpose, but without altering H within the region. This makes ρ and Γ zero in the outer region, keeps them unaltered in the inner region, and, owing to the sudden cessation of H at the boundary, introduces new matter and current there. Let σ_1 and γ_1 be the surface representatives of ρ and Γ. They are given by

$$N_1 H = 4\pi\sigma_1, \qquad VN_1H = 4\pi\gamma_1, \quad . \quad . \quad (18a)$$

corresponding to (12*a*), N_1 being the unit normal from the boundary to the inner region. If, now, we include this surface matter and current in the former ρ and Γ, the results are applicable to the inner region outside which H has been abolished, or to all space if we like to keep the outer H zero. P must be the potential of ρ and σ_1, and A the potential of Γ and γ_1.

As H in the inner region is the same as before H in the outer region was abolished, it follows that the force in the inner region due to the surface matter and current is identically the same as that due to the abolished ρ and Γ in the outer region. And, as there is now no force in the outer region, it follows that the force in the outer region due to the surface matter and current is the negative of that due to the matter and current in the inner region. If, for example, there was originally no ρ and no Γ in the outer region, the force in the inner region due to the surface matter is the negative of that due to the surface current, so that together they produce no force in the inner region, whilst in the outer region their joint effect is the negative of that of the ρ and Γ in the inner region.

Similarly we may treat the outer region as self-contained, by making $H = 0$ in the inner region, and introducing surface matter and current given by

$$N_2 H = 4\pi\sigma_2, \qquad VN_2H = 4\pi\gamma_2,$$

N_2 being the unit normal from the boundary to the outer region. Since $N_2 = -N_1$, σ_2 and γ_2 are the negatives of the former σ_1 and γ_1. The force in the inner region due to σ_2 and γ_2 is the negative of that due to the ρ and Γ in the outer region, whilst in the outer region it is the same as that due to the abolished ρ and Γ in the inner region. It will be convenient to have a fixed way of reckoning the normal and the surface matter and current. Let the normal be always + from the boundary to the outer region, and be called N, the same as the former N_2. Similarly call the surface matter and current σ and γ, corresponding to N, being the former σ_2 and γ_2, so that $\sigma_1 = -\sigma$, and $\gamma_1 = -\gamma$.

Internal and External Energies.—Let ρ_1, Γ_1 and ρ_2, Γ_2 be the matter and current densities in the inner and the outer regions, σ and γ the surface matter and current (as just defined), P_1, A_1, P_2, A_2, and P_0, A_0, the potentials of the inner, the outer, and the boundary matter and current, after (13*a*). Then the energies in the internal and the external regions are

$$\tfrac{1}{2}\Sigma(A_1 - A_0)(\Gamma_1 - \gamma) + \tfrac{1}{2}\Sigma(P_1 - P_0)(\rho_1 - \sigma),$$
and
$$\tfrac{1}{2}\Sigma(A_2 + A_0)(\Gamma_2 + \gamma) + \tfrac{1}{2}\Sigma(P_2 + P_0)(\rho_2 + \sigma), \quad . \quad . \quad (19a)$$

respectively, by (16*a*). But also, by disregarding the boundary altogether, the total energy in both regions is

$$\tfrac{1}{2}\Sigma(A_1 + A_2)(\Gamma_1 + \Gamma_2) + \tfrac{1}{2}\Sigma(P_1 + P_2)(\rho_1 + \rho_2) \quad . \quad . \quad (20a)$$

So the sum of the two expressions in (19*a*) equated to that in (20*a*) gives us the necessary relation

$$\Sigma(A_1\Gamma_2 + P_1\rho_2) = \Sigma\{\gamma(A_2 - A_1) + \sigma(P_2 - P_1) + A_0\gamma + P_0\sigma\};$$

both members being expressions for the mutual energy of the matter and current in the two regions. If there is no ρ or Γ in the outer region, this is equivalent to

$$0 = \Sigma(A\gamma + \Gamma\sigma - A_0\gamma - P_0\sigma),$$

and the external and the internal energies are

$$\tfrac{1}{2}\Sigma(A_0\gamma + P_0\sigma), \qquad \text{and} \qquad \tfrac{1}{2}\Sigma(A\Gamma + P\rho) - \tfrac{1}{2}\Sigma(A_0\gamma + P_0\sigma),$$

respectively. The first of these we may also write as $\frac{1}{2}\Sigma P\sigma$, if $H = -\nabla P$, as it can be expressed, or else as $\frac{1}{2}\Sigma A\gamma$, if curl.A $= H$, which is possible when $\Sigma\sigma = 0$.

Mechanical Force between the Regions.—There being matter and current in either or both regions, the resultant force on the inner region is

$$\Sigma(\rho_1 H + V\Gamma_1 H), \quad . \quad . \quad . \quad . \quad . \quad (21a)$$

the summation extending throughout the region. It is zero on any region in which there is no matter or current. Similarly

$$\Sigma(\rho_2 H + V\Gamma_2 H) \quad . \quad . \quad . \quad . \quad . \quad (22a)$$

is the resultant force on the outer region, the summation extending through *it*. Since the summations in (21*a*) and (22*a*) together include all space, the one sum is the negative of the other. Or, as (21*a*) is the resultant force *of* the outer *on* the inner region, and (22*a*) is that *of* the inner *on* the outer region, the one is the negative of the other. That is to say, action and reaction are equal and opposite; or, stress is mutual; or, a complete dynamical system cannot set itself moving, when taken as a whole. Both (21*a*) and (22*a*) are expressed by

$$\pm\tfrac{1}{2}\Sigma(\sigma H + V\gamma H), \quad . \quad . \quad . \quad . \quad (23a)$$

taken over the boundary, using the + sign to express the force of the outer on the inner region, and the − sign to express that of the inner region on the outer. Comparing (23*a*) with (22*a*) and (21*a*), we see that boundary matter and current takes the place of the matter and current in the inner or the outer region as the case may be. We may verify the equivalence of (23*a*) to the others by differentiation, applying the perennially useful and labour-saving Theorem of Convergence to either

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region with the common boundary; but the reason of (23a) and its necessity may be more simply seen thus. When we abolish the external field, and put $-\sigma$ and $-\gamma$ on the boundary, we make the inner region, with the boundary matter and current, a complete system, on which there is no resultant force. The resultant force on the surface matter and current $-\sigma$ and $-\gamma$ is therefore the negative of that on the internal ρ and Γ. But the surface matter and current are, so far as the mechanical force between the regions is concerned, equivalent to the external matter and current. Hence the resultant force on σ and γ is the same as that of the ρ and Γ in the outer region on the ρ and Γ in the inner. Hence, in (21a) we may put σ and γ for ρ_1 and Γ_1. But then, since by this we turn the volume integral into a surface integral, we must take the mean value of H through the infinitely thin layer of the surface matter and current. This is $\frac{1}{2}$H, since $H=0$ outside when the surface matter and current are taken instead of the external ρ_2 and Γ_2. Hence the presence of the $\frac{1}{2}$ in (23a.)

The vector in that expression, viz.,

$$\tfrac{1}{2}(\sigma H + V\gamma H), \quad . \quad . \quad . \quad . \quad . \quad (24a)$$

is the vector stress, according to the last section, regarding one side of it only, the force of the outer on the inner region per unit area of the boundary. Putting $\sigma = NH/4\pi$, $\gamma = VNH/4\pi$, it takes the form

$$H.(HN/4\pi) - N.(H^2/8\pi) \quad . \quad . \quad . \quad . \quad (25a).$$

Hence it is a simple Maxwellian stress of intensity $H^2/8\pi$.

It is not necessary, in reckoning the resultant mutual force between the regions, to take H in the formulæ, *i.e.*, to take the intensity of the force due to the matter and current in both regions. Thus, H_1 being the force intensity due to ρ_1 and Γ_1, and H_2 that due to ρ_2 and Γ_2, the resultant forces on the inner and outer regions are

$$\Sigma(\rho_1 H_2 + V\Gamma_1 H_2) \qquad \text{and} \qquad \Sigma(\rho_2 H_1 + V\Gamma_2 H_1)\,. \quad (26a)$$

respectively. Comparing with (21a) and (22a) we see that this is equivalent to saying that

$$0 = \Sigma(\rho_1 H_1 + V\Gamma_1 H_1), \qquad 0 = \Sigma(\rho_2 H_2 + V\Gamma_2 H_2)\,. \quad (27a)$$

Remember that in the inner region H_2 is the same as the force intensity due to $-\sigma$ and $-\gamma$; whilst in the outer region H_1 is the same as that due to $+\sigma$ and $+\gamma$. The (26a) expressions are equivalent to the boundary summations

$$\Sigma(\sigma H_2 + V\gamma H_2) \qquad \text{and} \qquad -\Sigma(\sigma H_1 + V\gamma H_1)\,;$$

or, in terms of the surface H_1 and H_2 only, to

$$\pm\,\Sigma\{H_1(NH_2) + H_2(NH_1) - N(H_1H_2)\}/4\pi. \quad . \quad (28a)$$

H and P in either region due to ρ and Γ in the other.—For distinctness, let there be no ρ or Γ in the outer region. H is then given by

$$H = -\Sigma(\rho f + V\Gamma f) = -\nabla\Sigma p\rho + \text{curl}.\Sigma p\Gamma \quad . \quad . \quad (29a)$$

H being reckoned at a fixed point Q, and p and f being the potential and force intensity at the place of ρ and Γ due to unit matter at Q. That is,

$$p = 1/r, \qquad f = r_1/r^2$$

if r be the distance from Q to the place of ρ or Γ, and r_1 a unit vector along r from Q. For ρ and Γ we may substitute the surface matter and current, when the point Q is in the outer region, thus

$$H = -\Sigma(\sigma f + V\gamma f) = -\nabla\Sigma p\sigma + \text{curl}.\Sigma p\gamma \quad . \quad . \quad (30a)$$

Thus, since σ and γ depend only upon the boundary H, if H be given only over a closed surface, we know H through the whole external space, so far as it depends upon ρ and Γ within the surface, and therefore definitely throughout the external space when there is ρ and Γ only within the surface (or, in the extreme, upon it). As we change the form of the boundary, the distributions of the surface σ and γ change. There may be matter only, viz., when H is normal everywhere, or the boundary is an equipotential surface (say due to an electrically charged conductor). There would be current only if H could be everywhere tangential, but this is not possible if H be magnetic force, at least without having current in the outer region. In general, we have both matter and current. Although the external field is definitely fixed by the surface H, we can get no information from it as to the internal field, except that $\Sigma\sigma = \Sigma\rho$, or the matter on the surface is the same in amount as that within it. If this be not zero, there is matter of amount $-\Sigma\sigma$ or $-\Sigma\rho$ on the surface at infinity, if we stop the extension of space. A closed current is equivalent to equal amounts of + and − matter; so is a magnet.

In the second form of (30a), the force H is derived from the scalar potential of σ and the vector potential of γ. We can, however, derive it from a scalar potential only, thus. Since the surface H, say H_0, is given, the surface potential can be found, except as regards a constant, by a line integration on the surface from a fixed point, whose potential is taken as zero. Thus, P_0 being the surface potential,

$$P_0 = -\int H_0 ds\,; \quad . \quad . \quad . \quad . \quad . \quad (31a)$$

$H_0 ds$ being the scalar product of H_0 and ds the vector element of the line of integration. Then, if P is the potential at the external point Q, we shall have

$$P = \Sigma p\sigma - \Sigma(fN)P_0/4\pi, \quad . \quad . \quad . \quad (32a)$$

and $H = -\nabla P$. The first Σ gives that part of the external potential due to the surface matter, $\sigma = H_0N/4\pi$. The second part is the scalar potential of the current; that is, if it be electric current, it is its magnetic potential. Or, it is the external magnetic potential of a closed magnetic shell, normally magnetised to strength $P_0/4\pi$. For, if I be the vector magnetic moment of a small magnet, its potential at Q is $-If$; in the present case $I = NP_0/4\pi$, and $P_0/4\pi$ is the moment per unit area. It is the same as Maxwell's "current function" of a current sheet. Test (32a) by the Convergence Theorem. The indeterminateness of P_0 as per (31a) as regards a constant does not affect (32a), the external potential of a closed magnetic shell of uniform strength being zero.

The external P in terms of the Surface P_0.—Let it be the surface P_0 that is given, not H_0 the surface force. A part of P is known, viz., the second term on the right of (32a). But the first term being in terms of the force, through σ, must be got rid of. Let x denote the operator that finds the external potential of the magnetic shell, that is, $x = -\Sigma(fN)/4\pi$ operating upon P_0 finds xP_0 the external potential of the shell of strength $P_0/4\pi$; this potential xP_0 is not the same as P. Let x_0P_0 denote the surface value of xP_0, not the same as P_0. Then we may denote by x_0^{-1} the operator which, acting upon P_0, finds $x_0^{-1}P_0$ the strength of shell whose potential *is* P_0 at the surface. Then, at an external point,

$$P = xx_0^{-1}P_0.$$

To render this process intelligible, expand x_0^{-1} thus

$$x_0^{-1} = \{1 - (1 - x_0)\}^{-1} = 1 + (1 - x_0) + (1 - x_0)^2 + \ldots.$$

Thus we have

$$P = x\{P_0 + (1 - x_0)P_0 + (1 - x_0)^2P_0 + \ldots\}, \quad . \quad . \quad . \quad . \quad (33a)$$

giving the external P in terms of the surface P_0 by direct operations, when for x we put its rational equivalent $-\Sigma(fN)/4\pi$.

The first approximation is xP_0. The next is $x(P_0 - x_0P_0)$, and so on. It is a process of exhaustion. But it only works when $\Sigma\rho = 0$. (33a) therefore solves the problem of finding the potential throughout a region bounded by a closed surface (taking N as the inward normal) in terms of the surface potential, the ρ and Γ being on the other side. And, when ρ and Γ are inside, it finds the external potential if $\Sigma\rho = 0$.

Annihilation of the Surface Current.—To get rid of γ and substitute matter giving the same external potential. Thus, given H_0. The first of (30a) gives H in terms of H_0 through σ and γ. The first distribution of matter is $\sigma = NH_0/4\pi$, and the force due to it is $-\Sigma f(NH_0)/4\pi$. Call this yH_0, and let its surface value be y_0H_0. Then

$$H = yy_0^{-1}H_0 = y\{H_0 + (1 - y_0)H_0 + (1 - y_0)^2H_0 + \ldots\}, \quad . \quad (34a)$$

in direct operations.

Or thus, H_0 gives a first σ and γ. Find the field due to the first γ. It has a normal and a tangential component, and

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therefore gives a second σ and γ. Find the field due to the second γ, which gives a third σ and γ; and so on. As we proceed, the γ left gets smaller and smaller, and is finally annihilated, leaving a distribution of matter, the sum of all the σ's, say σ_0. Then $H = -\Sigma f\sigma_0$, where σ_0 is given by

$$\sigma_0 = N(1-z)^{-1}H_0/4\pi, \text{ where } z = \Sigma f VN/4\pi.$$

Or, $$\sigma_0 = N(H_0 + zH_0 + z^2H_0 + \dots)/4\pi. \quad . \quad . \quad . \quad . \quad (35a)$$

Annihilation of the Surface Matter, when possible.—Starting with F_0, it gives a first σ and γ, and the H due to the latter is

$$\Sigma Vf\gamma = \Sigma VfVNH_0/4\pi = wH_0 \text{ say.}$$

Let w_0F_0 be the surface value. Then

$$H = ww_0^{-1}H_0 = w\{H_0 + (1-w_0)H_0 + (1-w_0)^2H_0 + \dots\} \quad (36a)$$

Or thus; in the manner (35a) was got, but annihilating σ instead of γ, we shall have $H = \Sigma Vf\gamma_0$, where γ_0 is the finally arrived at current given by

$$\gamma_0 = VN(1-y)^{-1}H_0/4\pi; \quad \text{where} \quad y = -\Sigma f.(N/4\pi).$$

Or

$$\gamma_0 = VfVN(H_0 + yH_0 + y^2H_0 + \quad . \quad . \quad . \quad . \quad)/4\pi \quad . \quad . \quad (37a)$$

y here is the same as in (34a).

P in Terms of the Surface H_0.—When the ρ and Γ are in the inner region, the first approximation to the value of P at the external point Q is $\Sigma pNH_0/4\pi$, say uH_0; and the force due to this is $-\nabla uH_0$. The complete external potential is

$$P = u(-\nabla u_0)^{-1}H_0 = u\{1 + (1 + \nabla u_0) + \dots\}H_0 \quad . \quad . \quad (38a).$$

But if the point Q be inside, and the ρ and Γ outside, this formula does not give the internal P (with N as the inward normal), but leaves it indeterminate as regards a constant.

A in Terms of the Surface H_0.—The first approximation to A (such that $H = \text{curl.}A$) being $\Sigma pVNH_0/4\pi$, say qH_0, and the force due to this being $\text{curl.}qH_0$, the complete external A at Q, when ρ and Γ are inside, and $\Sigma\rho = 0$, is

$$A = q(\text{curl.}q_0)^{-1}H_0 = q\{1 + (1 - \text{curl.}q_0) + \quad . \quad . \quad . \quad \}H_0 \quad . \quad . \quad . \quad (39a)$$

But if $\Sigma\rho$ or $\Sigma\sigma$ is not zero, we shall have

$$H = \text{curl.}A - \nabla P_1,$$

where A is given by (39a), and P_1 is the potential due to $\Sigma\rho$ distributed equipotentially. The external energy will now be expressed by

$$\tfrac{1}{2}\Sigma A\gamma + \tfrac{1}{2}P_1\Sigma\rho$$

when $\gamma = VNH_0/4\pi$; the mutual energy of the fields of A and P_1 being zero.

Remarks on these formulæ.—The process indicated by the right member of (33a) consists in the substitution of magnetic shells for matter, and finding their potentials. Let the final result be P_1, and P_{10} be its surface value. Then $P_{10} = P_0$ if $\Sigma\rho = 0$. Otherwise, their difference must be a constant, say $P_0 - P_{10} = P_{20}$. For xP_{20} must be zero, therefore P_{20} is constant. It is the potential of the surface when the quantity of matter $\Sigma\rho = \Sigma\sigma$ is distributed over it equipotentially.

Similarly, in the (36a), (37a) annihilation of the surface matter, so far as is possible, we arrive at the force which differs from the real force by that due to the matter $\Sigma\sigma$ which is left, and which is distributed equipotentially.

It will be observed that whilst the first σ and γ together produce no field on one side of the surface, the annihilation of either completely alters this. The complete σ_0, for example, produces a field on both sides, although it is the same on one side as that due to σ and γ, *i.e.*, on the side where H was under investigation.

There is always a distinction between the external and the internal regions as regards the determination of P from the surface *force*. It fixes the external force, when ρ and Γ are inside, and it also fixes the potential, so as to vanish at an infinite distance. It also fixes the internal force when the ρ and Γ are outside, but cannot then fix the potential. (*e. g.*, no surface force, yet a constant internal potential, depending upon external matter.) This puts a difficulty in the way of the estimation of the external P in terms of the surface P_0 when the ρ and Γ are inside, and $\Sigma\rho$ is not zero, even when we apply Green's method. We do not arrive at the proper Greenian distribution of matter, but at another, giving a surface potential differing from what is wanted by a known constant, so that we have to find another distribution, to give this constant potential.

(To be continued.)

CORRESPONDENCE.

THE DYNAMO AS A GENERATOR AND AS A MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have studied Mr. Mordey's paper on the above, which you have been good enough to reprint in the current number of the *The Electrician*, with very great interest.

I observe that Mr. Mordey, after, I presume, a series of experiments with which he has not favoured us, has come to the conclusion that the construction of both generators and motors should be exactly similar, or, in other words, that given a dynamo constructed in accordance with certain now well established principles for generators, it may be used either as generator or motor by simply altering the connections or the lead of the brushes.

As this conclusion is in direct contradiction to that arrived at by Messrs. Ayrton and Perry, it would certainly be interesting to dynamo manufacturers and others who are studying the subject if Mr. Mordey would favour us with a *résumé* of the experiments he has made, or of the argument upon which he has based his conclusions.

I may say that such a result, if it should prove to be correct, will be a great boon to dynamo manufacturers; inasmuch as they will only require to keep one set of patterns instead of two.

Unfortunately, however, as it appears to me, Mr. Mordey has been singularly unfortunate, from a controversial point of view, in the account of the experiments with which he has favoured us.

He leads us to expect a certain result. He states definitely that his experiments point to that result, and straightway proves that they do not.

He states:—"A little consideration suggested the probable existence of another analogy. Since a dynamo, having the above theoretically perfect form and action, with a *constant field* (the italics are mine), would produce a constant E.M.F. if run at a constant speed, independently of the load or amount of current generated, a motor constructed on the same principles and having a constant field, if supplied with energy at a constant difference of potential, should run at a constant speed, independently of load."

Later, he says:—"The results ultimately obtained, which are given in the following tabulated account of the experiments, and in the curves plotted for them, show that this fifth analogy is as true as the preceding ones, a constancy of speed being obtained which was very remarkable."

I should here call attention to the error which I have italicised in the first paragraph. No one knows better than the author of the paper himself, that in the compound shunt-wound dynamo, arranged to maintain a constant E.M.F. at constant speed with varying current, the field is *not* constant.

The total E.M.F. furnished by the dynamo itself is not constant, and cannot be, unless the resistances of armature and main wires on field magnets are reduced to nothing, if the E.M.F. is to remain constant between two points in the circuit—the terminals of the machine. As the current increases the charge upon the E.M.F. developed increases; and to make up for this the initial E.M.F. must increase. With the speed constant, there is only one way in which the E.M.F. can be increased, and that is by increasing the number of lines of force passing into the armature; in other words, by increasing the strength of the magnetic field. Coming now to the experiments. After making the decided statement above referred to, that the motor under trial maintained a constant speed with constant E.M.F., a constant field—everything constant, in fact, which goes to make up the amount

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of work done—but with a load varying from 1·8 horse-power to 16·3 horse-power in one case, and from 1 horse-power to 11·7 horse-power in the other, he proves by figures later on that the speed is not constant, but varies, more or less irregularly, inversely with the load. And then he proceeds to state that in the case of motors working with a constant field, the work done will be proportional to the speed.

I confess on reading through the record and particulars of the experiments I was very much puzzled to know how the load could be varied, everything else remaining constant.

The details given with the experiments are somewhat meagre. We are not told, for instance, what the resistance of the field magnet wires was, so that we have no means of knowing the power absorbed in furnishing the magnetic field.

Taking the experiment, however, as it is given. A pair of supply mains, from an independent source, arranged presumably to maintain constant difference of potential at their junction with the motor, the supply current dividing, part passing round the wires of the field magnets and part through the bobbin. The E.M.F. at brushes remaining constant, the current passing round the field magnet wires will be constant, and that passing through the bobbin will depend directly on the difference between the E.M.F. of supply and the back E.M.F. of the motor, and inversely on the resistance of the armature

or as $$\frac{E - E_1}{R\,a}$$

where E is E.M.F. of supply, E_1 back E.M.F. of motor, and $R\,a$ = res. of armature, in which should be included everything, such as coefficient of self-induction, which goes to reduce the working current. Now, E does not vary, $R\,a$ does not vary—in fact, such variations as would occur would reduce the current strength; therefore, the only way in which C_a, the current through the armature, can be increased is by decreasing E_1, the back E.M.F., and the only way in which the back E.M.F. can be reduced is by reducing the speed, as Mr. Mordey's experiments show. But it is surely not correct to claim at the same time constancy of speed with varying load, and under precisely the same conditions variation of speed with varying load.

The lesson which it appears to me should be drawn from Mr. Mordey's experiments is that with a dynamo constructed as this one was, viz., with a powerful magnetic field and armature of very low resistance, a small variation of speed—a variation that would be quite inappreciable in many mechanical apparatus that an electric motor would be required to drive—would give rise to a sufficient variation in the opposing E.M.F. of the motor to allow of large variation in the strength of the currents passing, and therefore of a *practically* uniform speed, with great variations in the load.

Perhaps, this is what Mr. Mordey meant to convey; but it is not the same thing, and it is not merely a play upon words. In fact, in my opinion, the distinction should be carefully remembered, if we are to avoid pitfalls in the future; and it should be remembered that it can only apply to a dynamo constructed in this way.

There are other points of great interest in connection with the experiments detailed. The very marked difference in the efficiency of the motor when running light and with a heavy load, it being greatest with the heaviest load. Bearing in mind that the work done in the armature varies as the square of the current passing, presuming the resistance to remain constant, and that both resistance and induction between the coils would increase, if anything, with the increase of current strength, we should expect to find the efficiency higher with smaller work. On the other hand, the charge for mechanical friction, and what Messrs. Ayrton and Perry have termed magnetic friction, being nearly constant for all loads, would bear heaviest on the lighter. Again, if motors of the latest improved type will only return from 30 per cent. to 60 per cent. of the electrical energy delivered to them, while generators give 80 per cent. to 85 per cent. commercial efficiency, a system of such a generator and such a motor connected together for the purpose of transmitting power would only have the same efficiency, leaving out any loss occasioned by the resistance of the connecting wires, as was obtained with the dynamo machines extant nearly eight years ago, in whose construction no thought had been taken of their acting as motors; so that in this branch, if the above is the best we can do, it can hardly be said that we have moved forward any.

With regard to the causes of the greater charge for conversion from electrical energy to mechanical energy, then from mechanical energy to electrical energy, Mr. Mordey's view that eddy currents have something to do with it is probably correct; but it can hardly account for all, as with properly constructed cores, the only path open to these eddy currents should have such a high resistance that they must be very weak; and further, if there be such a serious loss in this direction—due to powerful currents having been developed in or on the surface of the core—surely we should have the latter heated very much more when acting as a motor than as a generator; yet we find in Mr. Mordey's experiments that he was able to use a current more powerful than it was considered safe to allow when the dynamo was acting as a generator.

I should be more inclined myself to look for the loss in the interaction between the armature and field magnets, and the consequent weakness or displacement of the magnetic field.

In conclusion, I would congratulate Mr. Mordey upon having made one great step in advance in constructing a motor to perform work differing so widely in amount with such a small variation of speed. It is hardly possible to overrate this great advance in the, as we hope, approaching invasion of the industrial world by electricity as a competitor with other systems for transmitting power; and it appears to me that, assuming Mr. Mordey's figures to be correct, it is only a question of construction to reduce the variations of the speed, under varying load, and with constant E.M.F. of supply to something *absolutely* inappreciable. But such success will be due, if obtained, not to any newly-discovered law, in virtue of which any motor having a constant field will perform any work up to its full power without varying its speed, but to the special construction which enables a very *small* variation of speed to allow of the great variation of current strengths; and for showing us that this may be done, Mr. Mordey deserves our warmest thanks.—Yours, &c.

Cardiff, Jan. 19, 1886. SYDNEY F. WALKER.

THE SCIENCE OF ELECTRICAL ENGINEERING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have not, like "A Young Electrical Engineer," been so unfortunate as to come across a man in a responsible position who attempted to make electric engineering a success by keeping it as much a mystery as possible, but I have several times been surprised and annoyed to find intelligent workmen keeping back information, or even giving misleading instructions, to the *employés* of the purchasers of installations, with the idea of keeping their own firm busy.

The shortsightedness of such a course cannot be too often exposed. That there are businesses in which the plan can be carried out with success I do not deny, but electric lighting is certainly not one of them.

The sooner we have plenty of workmen to send out who can do electrical work with the same certainty and precision that other mechanical work is done, without expensive supervision, and the sooner the general public is sufficiently educated in electrical matters to know what they are getting for their money, so much sooner, I am convinced, will the electric light become sufficiently generally used to enable work to be done at reasonable prices, and not one or two, but many firms, to get a return on their capital.—Yours, &c., LUX.

January 18th, 1886.

NOMENCLATURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would you kindly inform me what is being done by the Notation and Nomenclature Committee.—Yours, &c.,

SCEPTIC.

[*For continuation of* CORRESPONDENCE *see page 213.*]

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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1885.

In concluding these somewhat lengthy notes of the past year we must again call attention to our reasons for giving them. Our object is not to prefer one company or firm to another, but to counteract as far as possible the tendency of the public to rush from one extreme to another. A few years ago the idea was universal that finality had been reached, and, because the whole community did not rush to have their houses fitted with electric light, and because local authorities were chary in introducing the system into the streets, the public opinion veered round to the idea that the whole was a delusion and a snare. Our efforts have been to show that good work is quietly and unostentatiously carried on, that the applications of electricity are not in the slough of despond, as some would have us believe. We want to strengthen public confidence in the work, in showing that good work stands the test of time, that those who have tested such work extend it more and more, to show that slowly and surely electric lighting is gaining ground, and that it will and must gain ground. We have no hesitation in saying that, so far as common sense and scientific knowledge go, it is the only light worthy of the civilisation of the nineteenth century. We are witnessing the true method of development, and, as many of our correspondents said last year and are saying again this year, the prospects are continually getting brighter. We have, as far as possible, given the information in our correspondents' own words, and it will be seen that in almost every case the outlook is held to be fairly good. We trust that the year may prove the forecast to be correct, and that in future our task may be lightened to consider more the progress from a scientific point of view than a commercial. The experience of America does not concern us so intimately as does the experience here, but it may be as well to show that our cousins across the Atlantic are progressing more rapidly, so far as installing the electric light is concerned, than we are. Of course there are many reasons which conduce to this state of affairs, not the least of which is that the cost of gas in the older towns is greater than in England, and in the more recently built places the electric light is preferred at once to gas. While we in England are talking a good deal about central station lighting, the Americans are arriving at some satisfactory or unsatisfactory results from actual experience. The following notes give the work of one of the Edison sub-companies during the past year. Our readers will see that we have retained the exact form of the notes as supplied officially to us by the Western Edison Light Company, Chicago:—

Appleton, Wis.—Central station three-wire system, 1,600 candle-power lights. Distance from central station to ends of feeders 2,100, 2,600, and 3,000ft.; total average distance from central station to lamps 5,500ft.; area covered by system is one square mile; water-power used two wheels; system enlarged recently to present capacity from 500 lights capacity; contract system.

Boone, Iowa.—Central station three-wire system, 600 10 candle-power lamps. Central station in Boone Linseed Oil Mill; power used, Reynolds-Corliss engine; distance from central station to centre of lighting 2,400ft.; plant started Nov. 4 with 500 lamps connected; entire capacity taken up now; will enlarge soon; meter system throughout; charge one cent. per lamp hour.

Rockford, Ill.—Central station, with three-wire system, 1,000 16 candle-power lamps. Power used, Reynolds-Corliss engine and New York S.S.P. Company, belted to countershaft; started with full load Dec. 31, 1885; territory covered by system 1¼ mile by ½ mile; average distance of lighting from central station is 3,000ft.; plant put in by a Van Depoele arc light company; meter system; charge one cent per lamp hour 16 candle-power, equivalent to gas at $2.00 per m.

Elgin, Ill.—Central station, three-wire system, 1,000 16 candle-power lights operated by water-power; to be started the first week in January, 1886; meter system.

Two Rivers, Wis.—Isolated plant in mills on both sides of river, 300 lamps, system covering ½ mile by ¼ mile. Lamps on other side of river from dynamo fed by armoured kerite cable which carries 110 amperes; heaviest current ever used through submarine cable; perfect success; has been in operation about six weeks; only incandescent lights fed by submarine cable in this country.

Chicago City Hall.—Two special engines, Armington and Sims, built to develop total of 225 horse-power with 35lb. steam; four Edison dynamos, having capacity of 1,650 lamps of 16 candle-power; 310 lamps operated in the two tunnels at distance of 2,000ft. from dynamos run constantly night and day; 2,200lb. of kerite covered cable and wire used in tunnels and in the underground conductors to them; 9,000lb. cable pulled in at one time and in one length from hall to tunnel; 1,300 lamps wired in City hall; total loss of electromotive force in City hall with full load 3 volts; widest variation in pressure in various parts of hall 1·2 volt. One, two, three, or four machines can be operated at one time upon the plant, and keep lamps burning in hall and tunnels. Load shifted from one engine and dynamos to the other twice a day without any variation in light whatever. Machines of different sizes run perfectly together in multiple arc. Plant started Dec. 1st, and

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never has stopped a second since. It will run year in and year out.

Minonk, Ill.—Small central station, lighting a mining town, stores, and houses, light being introduced in a coal mine. It will be the first installation of incandescent lights in a coal mine in the country.

Six more central stations are to be put in in the course of the next few months. Among the isolated plants now being put in the following are given :—

	Lights.
Eastern Hospital for Insane, Kankakee, Ill.	673
National Soldiers' Home, Milwaukee, Wis.	200
United States Rolling Stock Company, Hegewisch, Ill.	671
Wm. Deering and Co., Harvester Works, Chicago	500
Pfister and Vogel Leather Company, Tannery, Milwaukee, Wis.	353
Best Brewing Company, Milwaukee, Wis. (Enlargement)	200
B. D. and W. N. Eisendrath, Chicago, Tannery and Glove Factory	150
J. V. Farwell and Co., Chicago, Wholesale Dry Goods	250
Chicago Opera House (day circuit)	75
O. F. Aldis, Chicago, Montauk Block	75
C. T. Reynolds and Co., Wholesale Paints and Oils, Chicago	150
Taylor Bros., M'Quincy, Ill., Flouring Mill	100
Wright and Lawther, Oil and Lead Manufacturing Company, Chicago	100
Crane Bros. Manufacturing Company, Chicago, Machine Shops	250
Heinemann Bros., Wausau, Wis., Mill and Store...	60
Union Elevator Company, East St. Louis, Ill.	100
C. Manegold and Son, Milwaukee, Wis., Flouring Mill	50

Central Station Totals.	Lights.
Appleton, Wis.	1,000
Rockford, Ill.	1,000
Elgin, Ill.	1,000
Boone, Iowa	600
Lockport, Ill.	400
Minonk, Ill.	300

The Electrical Power Storage Company.—During the past year probably few companies have improved their commercial position more than this company. Great hopes were entertained a year ago that the practical difficulties in connection with their secondary batteries had been surmounted, and the results have more than verified these expectations. A large proportion of the more recent installations carried out in England include accumulators, and the demand has increased to such an extent that the works of the company for some months have been running night and day. As a natural result of the extensive use of accumulators in England, confidence is rapidly spreading abroad, and among the orders in hand may be mentioned one of 100 tons supplied to the Imperial Continental Gas Association for a single installation in Vienna.

Among the batteries supplied during the past year may be mentioned those for the Society of Arts, Royal Institution, Lloyd's, H.M.S. "Vernon," Royal Engineers' Committee, South Kensington Museum, Leeds Institute, Sir R. Webster, supplied through Messrs. Crompton and Company; Lord Egerton, of Tatton; Lord Muncaster, Lord Wolverton, Sir Greville Smythe, The Electrotechnische Fabrik Cannstadt, The Nederlandesche, &c.

The company are also busily engaged in installation work, which has proved to be one of the most important branches of their business. They have lately completed, or have at present in hand, the lighting of the Prudential Assurance Company's offices with 1,500 lamps. The Bank of New South Wales, Messrs. John Bell and Sons, and private house lighting for Messrs. J. W. Logan, F. Green, H. Harben, F. Bumstead, J. Goddard, W. Alexander, &c., and have taken over the completion and working of the installation at Lloyd's, where upwards of 500 lamps will be fixed.

With the increased facilities for the production and storage of electricity, its use as a motive power is daily receiving more attention, and the Storage Company have during the past year, as the result of a long series of costly experiments, been instrumental in promoting its general application. The last tramcar manufactured by the company, which is now running successfully in Berlin, is the outcome of the experiments with the former car, which was run at Battersea in the early part of the year. The present car is fitted with the Reckenzaun gearing and Electrical Power Storage accumulators, and contains several improvements designed by Mr. Reckenzawn (who was formerly in the company's service) and the staff of the Storage Company. The experiments have conclusively shown that the accumulators are reliable for this class of work, and there is little doubt that during the ensuing year the company will be able to master the difficulties in connection with tramcar propulsion. They have built an electric launch for the Duke of Bedford, to be used in connection with the ss. "Northumbria," the accumulators being used either for propelling the launch or for lighting the yacht when the dynamo is not at work. Others are in course of construction, one of which is for the Sultan of Turkey.

An English firm that has come into prominence is that of Elwell-Parker. This firm lay themselves out for manufacturing dynamos and secondary batteries to suit every purpose for which they may be required.

To give an idea of the variety of purposes for which they manufacture dynamo machines, we may mention that during the past year they have supplied machines to Elkingtons, of London and Birmingham, amongst others, for electro-plating; to the Blackpool Tramway Company (40-unit slow-speed generators and 6 horse-power motors), for transmission of power; to the Cassel Gold Extracting Company (30-unit 1,000 ampere machines), for extracting gold from the ore; to the Trafalgar Colliery Company, Forest of Dean (6-unit generator at surface, driving 6 horse-power motor down the pit), for pumping underground; to the Cannock Chase Colliery Company, for underground lighting (carried out by their engineer, Mr. Sopwith, with perfect success); and to most of the electric light contractors for public buildings, railway stations, ironworks, house-to-house lighting, town mansions and country houses, breweries, &c., for which several hundred machines have been supplied during the year. These include machines for ship lighting.

An Elwell-Parker new 4-pole vertical machine, as supplied to Sir David Salomons for his country house, Broomhill, Tunbridge Wells, may be taken as a sample of the dynamos under notice. This machine has a 16in. armature, and, at a speed of only 350 revolutions per minute, gives 110 volts and 182 amperes. The commercial efficiency, even at this speed, is very high, showing eleven lamps (60 watts) per horse-power delivered to the pulley, whilst the wear and tear is reduced to a minimum. As far as safety is concerned, this machine may be driven at 1,000 revolutions per minute, when it would be equal to doing about 60,000 watts, but the wear and tear would then, of course, be greatly increased.

In accumulators, this firm has supplied cells which, in dimensions and storage capacity, perhaps, exceed all that has ever been attempted before; and experience in this line leads

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them to the conclusion that the larger the cells the more simple and easy are they to keep in perfect order.

The action between the Electrical Power Storage Company and the Elwell-Parker Company, for alleged infringement of one of their patents, and which ultimately resulted in an injunction being granted, led the Elwell-Parker Company to experiment in a new direction, with combinations of the best parts of both the Planté and Parker patents and those of Faure, Swan, and Sellon. After careful tests, extended over a considerable period, they discovered that a Planté positive plate, prepared by the Planté and Parker patents, opposed to a negative plate of the most approved form of the Faure, Sellon, and Swan patents, combined with Moseley's separator, gave the best results yet obtained in the storage of electrical energy.

This combination was patented by Messrs. Moseley and Parker. In the opinion of this firm a decided inclination towards slow speeds and thoroughly substantial work, added to the increasing demand for larger machinery and plant, shows a very promising condition of things.

Mr. Elwell has always held to the opinion that the manufacture of electrical machinery and plant should be kept distinct from the business of electric light contractors—otherwise, competition with one's own customers must result—and he believes that eventually most installations will be carried out by those firms who have always been accustomed to install artificial light, whether it be from oil, candles, gas, or electricity.

During the past year Messrs. J. D. F. Andrews and Co. have completed a large number of installations, of some of which descriptions have already appeared in our columns. Amongst others we may mention the following:—The Cunard Steamship Company's "Umbria" and "Etruria," 850 incandescent lamps and 2 arc lamps each; H.M.S. "Ajax," 290 incandescent lamps; H.M.S. "Conqueror," 160 incandescent lamps; ss. "Corangamite" and "Burrumbeet," belonging to Messrs. Huddart, Parker and Co., of Melbourne, Australia, 160 lights each; Captain Parker's steam yacht "Lady Beatrice," 35 lights; Messrs. R. and J. Dick's boot shop, High Holborn, London, 70 lights; Messrs. Simons and Co.'s dredger "Melbourne," 6 arc lamps, &c. It may be of interest to those who have read our descriptions of some of these installations to learn that they are giving entire satisfaction, and that they have not caused the slightest trouble since they were completed. The firm had their apparatus on exhibition for the first time at the International Inventions Exhibition. They have during the year supplied a number of Andrews dynamos and other apparatus through their agents, and on their own installations, and during the last few months they have largely increased their facilities for turning out these machines quickly in order to keep pace with the increasing demand. They have also recently made some very material improvements in the Andrews arc lamp, and have obtained most excellent results from the trials that have been made. The company has been especially busy during the last months of the year, and among the work done we may mention Messrs. Geo. Smith and Son's ss. "City of Bombay," lighted with 110 lights and a duplicate set of machinery; a block of mills at Lancaster amounting in all to about 500 lights; the lighting of three passenger steamers for the North German Lloyd, with about 450 lights each; an installation of arc lamps in Mr. Houghton's steel works at Carnforth; another arc installation in a paper mill at Leslie, &c. The company have also a number of orders for the Andrews dynamos and arc lamps, and they have every prospect of more business in the year upon which we are just entering than in the past year.

Of the younger firms pushing into prominence we may mention Messrs. Goolden and Trotter, who, commencing business in March, passed a somewhat quiet summer preparatory to a very busy autumn. The works are now kept going night and day, and have orders in hand for the next three months. The firm has almost, or quite, completed the fitting of H.M.S. "Devastation," and are busily engaged on H.M. ships "Mersey" and "Severn," while ten sets of engines and dynamos are being built for torpedo boats. Some very successful experiments in train lighting have been carried out on the Lancashire and Yorkshire Railway, which are likely to assist in the development of this class of work, the railway company having already purchased several machines. The firm is making a speciality of electrical fittings and measuring instruments. It is well known also that one member of the firm, Mr. Trotter, has carefully investigated, both theoretically and practically, the question of the use of dioptric glass in the diffusion of the light from incandescent and arc lamps. We shall refer to this work in a separate article, as we shall also to the new dynamo constructed by the firm specially adapted to ship lighting.

Messrs. Thompson, Dowsing, and Rew have been giving their especial attention to the question of office and domestic signalling by electricity, and have succeeded in perfecting two very novel applications, one being an automatic indicator which can be worked entirely from the room of the person to whom the indication refers, and automatically breaks its own circuit, thereby saving wasting in the battery; the other is worked in the hall by a number of pushes (each having special reference) actuating one common indicator, the object of this latter form being to inform visitors at a glance who may be in or out without mounting the stairs, a very desirable apparatus for almost all city offices. Both indicators are independent of porter's attention, and safe from interference. This firm has also perfected some novel forms of switches, which were illustrated in our number of September 25, a very elegant departure having been made by employing glass handles in conjunction with bright brass work and slate bases. The new orange tanned belting has also met with great success, and a new form of leather rope belting has lately been placed before the public which obviates the difficulties of jointing. This firm are the English agents for M. E. Levy, who is, we understand, about to bring out a new quality of Carré carbon intended to meet requirements of certain conditions of E.M.F. and current for which the existing Carré carbons are not altogether suitable.

Messrs. W. H. Allen and Co., of Lambeth, who are the makers of the "Kapp" dynamo, which obtained a silver medal at the Inventions Exhibition, have already found a market for the useful combination of Allen engine and Kapp dynamo, ten sets having been supplied to the Admiralty, and several being in hand for private shipping firms. Besides these, the firm have supplied a large number of belt-driven dynamos for customers in England, Denmark, Germany, and Italy. Two large dynamos for the Central Station at St. Austell are also being constructed by this firm.

The Rosenthal Mirror Galvanometer.—It is claimed that this galvanometer possesses extreme sensibility with a minimum of coil resistance. We have not seen the instrument, but if the published accounts of it hold good, it will be a useful addition to the laboratory. The magnet, which is below the mirror, is placed in close proximity of distance to two low resistance coils (3 ohms each), and has a very long suspension, viz., 255 mm. Each coil is formed of 200 turns of well-insulated silver wire wound upon an ivory bobbin.

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THE ANALOGIES OF GENERATORS AND MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The valuable paper by Mr. Mordey, which you published in your issue of the 8th inst., to me was very pleasing. Both Mr. Mordey and many of your readers will no doubt be interested to hear of those analogies and laws he has lately demonstrated having been practically used.

Nearly two years ago, having determined to use the Elwell-Parker dynamos as generators for transmitting power to drive underground pumps, and being at that time in search of a good motor for same, the questions arose, How should the motor be constructed to give the highest efficiency (its weight in this case being of little importance), and in what way should it differ from the generator? The matter was most carefully considered, and several experiments were made at the Trafalgar Collieries, Gloucestershire, where the machines were wanted, with the Schuckert, Siemens, and various Gramme dynamos as motors. By permission of Messrs. Elwell-Parker, at their works, I, with Mr. T. Parker, of that firm, further experimented on their machines. As we obtained a far higher efficiency than was expected, it led to a more careful investigation of the laws relating to the allied actions, during which we clearly proved the analogies Mr. Mordey now mentions. Moreover, the chief features which made that machine so efficient as a dynamo—viz., a very powerful field, with a comparatively small low resistance and highly magnetisable armature—we considered, and also practically proved, to constitute its value as a motor. Winding the armature with a single layer—thereby being enabled to obtain a most intense field, and the greatest work for the minimum length of wire, *i.e.*, lowest resistance in armature—appeared to us to be as valuable in a motor when driving a current through the field as it is known to be when used in a dynamo. Accordingly, the machines for the Trafalgar Colliery Company were built by Messrs. Elwell-Parker, the motors having field magnets of a similar shape to their dynamo, and, where compound-wound, keeping a constant field. By this mears the engineman on surface can tell by his ammeter what work the pumps below are doing. The armatures had the cores of soft iron wire carefully insulated with varnish (the top layers being of a smaller wire), and wound with a single layer of copper wire. These machines were easily reversed by reversing the current through the armature, not the slightest movement of the brushes being necessary, whether the full load was on or not. They were almost sparkless at the brushes, and have been working in the collieries ever since, running day and night, Sundays included, often working 22 hours out of 24, and are still at work, never even having had the commutators repaired. I may mention that Messrs. Elwell-Parker (with whom I am now connected) have ever since then constructed their motors on those principles. Those used at the Inventions Exhibition and also those now on the Blackpool Tramway are so built; but in the latter case the field-magnets are constructed of strips of wrought iron (Siemens type), being there limited for space and weight.

Our experience is that these machines, where properly handled, give most satisfactory results.

We did not arrive at an accurate method of determining the power absorbed by eddy currents in the motor armature, and should therefore be much interested in any data Mr. Mordey or any of your readers could furnish on this important subject.—Yours, &c., CARL T. BLANCH. BRAND.

Wolverhampton, Jan. 19, 1886.

A PRIVATE INSTALLATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Occasionally I observe in *The Electrician* accounts of large private electric light installations, and it occurs to me that it might be interesting to many of your readers to hear something of my less ambitious arrangements, particularly as I have had a long experience of the electric light, having been the first in Scotland to introduce it into a private house (in April, 1881), and that experience of a very favourable nature. The incandescent system only is employed, a Siemens S D_2 (shunt-wound) 50-volt dynamo, driven by a turbine wheel, supplying the current. The stream operating the turbine is not large, and is interrupted by thrashing operations above, so that a dam is necessary. After determining by long trial the limits of irregularity of the water supply, I two years ago adopted the present arrangement for power. From a large dam, easily formed in a sharp hollow by constructing a bank across the lower end, 8in. iron pipes are laid for about 400 yards to the turbine wheel, within 100 yards of the mansion house, and beside the home farm steading. The total fall, including 16ft. of suction, is 75ft. The turbine is of Prof. James Thomson's inward-flow vortex design, with adjustable guide blades for regulating the water supply. The axis is horizontal, and coupled directly to the spindle of the dynamo armature. To be able to derive the necessary power from half the supply of water otherwise attainable, and to avoid multiplying gearing were my objects in expending the considerable sum involved in so much iron piping. The absence of all gearing and the motion of nothing but the virtually single spindle of the dynamo and turbine, with their perfectly balanced coil and wheel, are immense advantages in eliminating almost all risk of derangement and some loss of power. The turbine is also used for thrashing, or sawing wood, by simply unscrewing four bolts connecting it with the dynamo spindle.

Bare copper cables convey the current to the bed room floor of the house, under which floor, from one end to the other, run well-covered leads, with branches to the chandeliers and brackets of the public rooms and hall below, and of the bed rooms and passages above.

The light having been introduced before there was much certainty as to its reliability, the chandeliers and brackets are so arranged that by screwing out the holders of the electric lamps, and inserting gas burners, gas may be quickly brought into use. Happily, however, this has been so far a useless provision, for from the minute of starting there has not been a single break down. Each lamp has a switch and safety fuse, and safety fuses are placed at the junctions of the branches and the mains, as well as on the main circuit close to the dynamo. A branch circuit is taken from the point where the wires enter the house to the kitchen, servants' hall, and other servants' rooms. Lights are also supplied to the laundry, stables, coachman's house, and farm courtyard.

The lamps used are Swan and Swan-Edison. The management of the installation is simple; my coachman acts as electrician. He starts the dynamo at dusk, cleaning the commutator, filling the oil cups, and pulling up the weight for closing the sluice at night, then leaving all till next day. The water is turned off from the house by an electrical arrangement releasing the weight referred to. A small wire from the house carries a current continually through a finely wound electromagnet in the dynamo room. By interrupting the current a heavy armature is released. To the screw which closes the sluice valve a wheel is fixed, round which when the valve is opened a rope attached to the weight is wound. The fall of the armature releases the weight, and the sluice is immediately closed (an improvement on this is being made, in which a hydraulic ram replaces the rope and weight). Should any severe short circuit occur, and the main fuse be melted, the armature will immediately fall and shut off the water supply. So much for the arrangement of the installation. The reliability of the electric light is sufficiently proved by the fact that, since I completed two years ago the system of power described above, there has not been a hitch in it. Its beautiful steadiness, coolness, and healthiness I need not refer to. In all these qualifications it excels gas. Regarding the interesting item of cost, the original outlay on water supply, turbine, and dynamo was much less than—about half—that of the cost of the gas works, and, as far as I can learn, the cost of wiring was about the same as that of gas pipes. The cost of maintenance has been very low. Unfortunately, I have mislaid last season's figures, which were higher than for this, owing to greater breakages of lamps. The small breakage this year is due, in part at least, to my incandescing the lamps to a lower standard than marked; but undoubtedly lamps are made now more durable. This year I spent

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£5. 10s. on renewal of the commutator, which has still several months' wear in it, less than 12s. on oil and waste, and 13s. 6d. on renewal of lamps, one of which was broken accidentally. As the coachman is only occupied a few minutes a day in cleaning the dynamo, I reckon nothing for attendance. Running 25 lamps on an average from April till the middle of November, say 600 hours, the cost has been about ⅓d., or, adding interest and depreciation, about ½d. per lamp per hour. Had I run the full number of 50 lamps the cost would have been about ¼d.; and were I in the country throughout the winter much less.

These rates are thus far below those for gas in country houses, and even below those in towns. The three points I trust I have brought out in this description are the reliability, simplicity, and economy of the electric light in country houses, where water-power is readily obtainable; and there are many such houses.

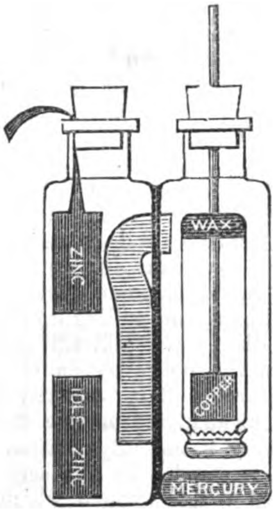
My hope is that this description may induce some of the fortunate possessors of houses favourably situated to introduce during the coming spring or summer so delightful a light.—Yours, &c., J. MARTIN WHITE.

Balruddery, near Dundee.

DANIELL BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am obliged for your notice of my Daniell battery. I am sorry that with the description you did not get the E.M.F. of the solutions mentioned. I would like very much to know what the value of the battery would be under the conditions given. Certainly, with the dilute copper sulphate mixed with zinc sulphate the E.M.F. would be somewhat low.



I enclose a sketch of a modified form of the cell, which I find very satisfactory for a portable cell. The copper plate and copper solution are enclosed in a phial, the mouth of which is covered with a membrane. The wire from the copper plate passes through a hole in the bottom of the phial and is sealed with wax. The phial is filled with concentrated copper solution and crystals of copper sulphate. The two bottles forming the cell are cemented together, and the tube which passes through the hole in both bottles is also cemented with wax. If desired, a little mercury may be put in the bottle which holds the copper, then by lowering the copper cell into the mercury it is sealed up and diffusion prevented.—Yours, &c.,

849, W. Congress-street, Chicago, Ills. C. WIRT.
December 26, 1885.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It may assist some of your correspondents to understand the mystery of this latest "new thing" advised from the "Modern Athens" if I mention the following, to which, if necessary, I might add more.

The boy in question was born subsequent to the time of Ruhmkorff, and the wideawake showman was fully alive to the advantages sometimes afforded by a good *understanding*.

My attention was casually drawn to the matter through observing the depraved appetite of the little savage—or it may have been his family "connections," though certainly not the showman—for things not generally classed as edibles.

Your worthy correspondent, Mr. Johnstone, will quite understand me I have no doubt; and as neither of us could wish to be the means of advertising the esoteric at the expense of the penny showman's business, he will understand why I am not more explicit.—Yours, &c., HAMLET.

THE ELECTRIC LIGHT FOR IRONWORKS.

At a meeting of the South Staffordshire Institute of Iron and Steel Works Managers, held recently at Dudley, Mr. G. B. Wright, mechanical and electrical engineer, Wolverhampton, read a paper on "Electric Lighting applied to Rolling Mills." It might, he said, have been surmised that the iron rolling mills of South Staffordshire, with their low pitched roofs, would have been the last field wherein to look for the profitable use of the electric light, but experience had proved otherwise, and there were several important works where it had been adopted. Sheet iron was the staple manufacture of the district, and it might have been thought impossible to supply the roller with the electric light just where the gas jet was always essentially placed. Such difficulties, however, occurred only with the arc system of electric lighting, and had been wholly removed by the incandescent or glow lamp system. There was no better example of the successful application of this light than in the case of the extensive sheetworks of Messrs. John Lysaght (Limited), of the Swan Garden Iron Works, Wolverhampton. The whole of their works, including foundry, fitting shops, and offices, as well as pig yards, bar banks, and canal wharves, are well lighted up by means of the incandescent lamp. For sheet rolls and shears the light is all that can be required, for the stocktaker's examination it answers admirably, and for yards and wharves, though less brilliant than the arc lamp, it serves exceedingly well. The current is generated by two Elwell-Parker compound-wound dynamos. There are 380 lamps upon the two machines, 60 of them being single lamps of 95 volts, and 320 running in pairs at 48 volts. The dynamos are driven at 950 revolutions per minute by a high pressure, horizontal engine, running at 90 revolutions, and supplied by steam at 40lb., raised by the waste heat from the heating and puddling furnaces. The apparatus is in charge of an ordinary engine driver, whose wages are 25s. per week. At Messrs. E. T. Wright and Sons, Monmoor Iron Works, Wolverhampton, the system is also in use. One half of the extensive works has thus been lighted up for fifteen months past, and the installation is running as steadily now as the day it started. In this case the dynamo generating the current is, with a small engine to drive it, placed upon the top floor of the mill engine house, and the engineer for the time looks after it without much trouble. A third example is that at Messrs. George Wilkinson and Co.'s new sheet mill at Tividale. Here the dynamo is driven from the fly-wheel of a small engine, which drives a pair of edging tools for grinding, fettling, &c., and which the mill engineer also looks after. At these several works there is no provision for storing the electricity, nor has the need of it been felt. In an ironworks storage is practically unnecessary. He was in a position to speak confidently of the cost of maintenance, for in each of the examples given he had supplied the apparatus and maintained it at a price well below the cost of gas. The president opened the discussion by suggesting that if the dynamos were driven directly off the mill engine, and not by a separate engine, the lights would go out when the mill engine had to be stopped. Mr. Wright replied that generally speaking separate engines were employed. Of course, if the mill engine stopped the light

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stopped. Further replying to the chairman he said that Messrs. Lysaght's installation had cost them £616. Taking the interest on outlay, and the cost of maintenance, the electric light was costing Messrs. Lysaght about one-half the expense of gas.

DYNAMO TESTS.

(Continued from page 196.)

MEASUREMENT OF CURRENT.

The currents were measured by observing the ratio of the potentials at the ends of a fixed resistance when a known current and the current to be measured were passing respectively. To do this, the terminals of a circuit containing a galvanometer and a resistance box were permanently fastened to the extremities of the fixed resistance. A current was sent through the latter, and the resistance of the box adjusted until the proper deflection of the galvanometer was obtained; the current was measured by the voltameter, tangent galvanometer, or calorimeter, and the deflection and resistance were observed. When any other current was to be measured, the box was changed until the deflection was about the same as before, and both the deflection and resistance noted. The thermometers used in getting the temperatures of the different parts of the circuit were those by Green, already described.

The notation and formulæ used are as follows:—

Let C' be the current used in calibration;
r' be the resistance used in calibration;
d' be the deflection used in calibration;
t'_s be the temperature of fixed resistance at calibration;
t'_b be the temperature of resistance box at calibration;
t'_g be the temperature of galvanometer at calibration;
C'' be the current to be measured;
r'' be the corresponding resistance;
d'' be the corresponding deflection;
t''_s be the corresponding temperature of fixed resistance;
t''_b be the corresponding temperature of the box;
t''_g be the corresponding temperature of galvanometer;
t_o be the standard temperature = 25° C.;
u_g be the temperature coefficient for galvanometer circuit;
u_s be the temperature coefficient for fixed resistance and box;
G be the galvanometer resistance;
k be the constant at 25° C.

Then

$$k = \frac{C'}{2d'} \frac{1 + u_s (t'_s - t_o)}{\left[G \{ 1 + u_g (t'_g - t_o) \} + r' \{ 1 + u_s (t'_b - t_o) \} \right]}$$

$$C'' = k\ 2a'' \left[1 - u_s (t''_s - t_o) \right] \left[G (1 + u_g (t''_g - t_o)) + r'' (1 + u_s (t''_b - t_o)) \right]$$

Calculations were facilitated by making tables of

$$G \{ 1 - u_g (t_g - t_o) \}$$

for the different temperatures, of

$$r \{ 1 + u_s (t_b - t_o) \}$$

for the different resistances that were to be used, and of

$$1 - u_s (t_s - t_o)$$

for the different temperatures of the fixed resistance.

Galvanometer.—A mirror galvanometer, by Edelmann, of Munich, was used. It was furnished with a ring magnet damped by surrounding copper blocks. The suspension, originally about two feet long, was shortened to about seven or eight inches by a copper rod passing inside the glass suspension tube; there was no trouble from vibrations. The coils were movable on graduated bars, but for the tests they were clamped and their position never changed. The resistance of the coils, with the fixed resistance and the leads to it, was

·3973 ohm, at 25°.

This was taken as G in the formulæ, and the temperature coefficient for copper used; the value of the German silver fixed resistance being only about ·0004 ohm, and the rest of the circuit being copper. The galvanometer was read with a mirror and scale, the latter being of porcelain, graduated to centimetres and millimetres. The distance from the galvanometer was 2·5 metres.

Resistance Box.—The resistance box, by Hartmann, being open at both ends and having no paraffin on the coils, was very well fitted for its work. Its measurement has been described.

Fixed Resistance.—The details of the fixed resistance are shown in Figs. 3, 4, and 5, which are, respectively, a plan, side elevation, and end view. It is also shown in perspective in

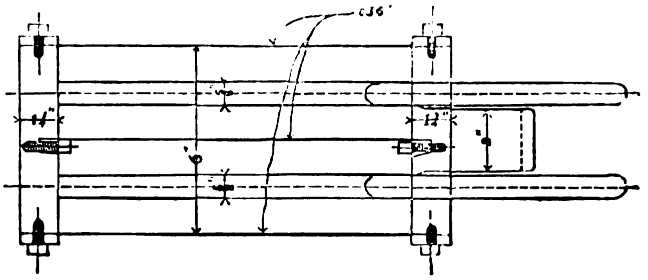

FIG. 3.—Plan

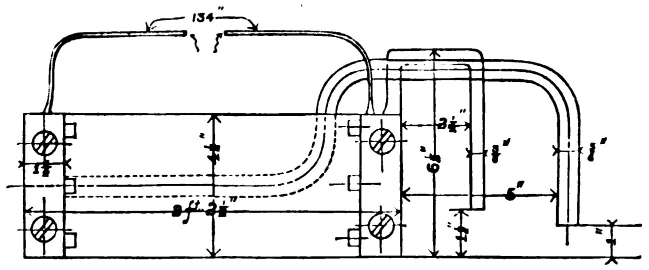

FIG. 4.—Side Elevation.

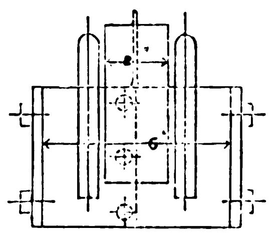

FIG. 5.—End View.

Figs. 1 and 2. It consisted of three strips of German silver, 4½in. broad by ·036in. thick, the ends hard-soldered into heavy copper blocks.

One of the blocks had a terminal piece cast on it that was bent to clear the edge of the tank in which the resistance was placed, and dipped into a mercury cup, to which one of the main leads was brought. From the other block, two copper rods passing between the strips were bent over the edge of the tank and dipped with the other main led into another mercury cup. The terminals of the galvanometer circuit were soldered into the copper blocks and remained permanent during the tests. The whole was put in a rectangular tank filled with the same kind of oil as was used for the potential resistance.

Calibrations.—Calibrations were made by sending a current through the fixed resistance, measuring it, observing the deflection of the galvanometer and the resistance in its circuit, and noting the temperatures. The calibrations usually lasted ten minutes. The constant was calculated by the formula already given.

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Three methods of measuring current were used; the silver voltameter, tangent galvanometer, and calorimeter.

For the voltameter calibrations, a large platinum dish was used as cathode, a flattened spiral of silver wire wrapped with filter paper as anode, while a forty to fifty per cent. solution of silver nitrate was employed. With this strength of solution and with the usual current, about four amperes, the deposit was very regular and beautiful. It was treated as described under potential measurements. The resistance in the circuit was about ten ohms.

The tangent galvanometer has been already described. Two observers read both ends of the needle on each side of the zero mark. The current was reversed every minute; it varied from twenty to thirty amperes.

The method of using the calorimeter has been described. The observations give C^2 R, and R being measured by the bridge, C may be found, with the advantage that errors of observation are halved in the value of C.

Altogether, there were five calibrations by the tangent, nine by the voltameter, and five by the calorimeter. The following are the values obtained:—

·024510	by voltameter.
·024510	by voltameter.
·024440	by tangent galvanometer.
·024550	by tangent galvanometer.
·024510	by voltameter.
·024480	by voltameter.
·024590	by tangent.
	by calorimeter.
·02455	by tangent.
·02455	by voltameter.
·024481	by calorimeter.
·024477	by calorimeter.
·024520	by tangent.
·024500	by voltameter.
·024516	by voltameter.
·02453	by calorimeter.
·024495	by voltameter.
·024494	by voltameter.
·02450	by calorimeter.

This principle of measuring current has been used before, notably at the Vienna and Munich Exhibitions, but as employed in the following tests the method differs from that previously used in an important particular, *i.e.*, the construction of the fixed resistance. The substitution in the fixed resistance of German silver strips in oil instead of the copper bars in air formerly employed, increased greatly both the range and accuracy of the method.

As the method has not been commonly used, and is possibly not very generally understood, a brief discussion of the sources of error and their probable value in these tests will be given.

The possible sources of error are:—

1. In observing the deflections;
2. In the constant;
3. In the temperature correction for fixed resistance;
4. In the temperature correction for resistance box;
5. In the temperature correction for galvanometer;
6. In the values of the coils in the box;
7. In the resistance of the galvanometer coils;
8. In assuming the currents proportional to 2d.

(1.) Error in observing the deflections.

This error would enter directly in the result. The scale could be read with considerable accuracy to tenths of millimetres; the double deflections were usually between twenty and thirty centimetres. The currents measured were quite steady, but even if they varied, the excellent damping of the galvanometer would allow the readings to be taken with a good deal of precision.

(2.) Errors in the constant.

On looking at the table of constants, it will be seen that the results obtained with different resistances in the galvanometer circuit, different currents, temperatures and deflections, and by entirely independent methods of measuring current, agree so closely that their mean must be very near the true constant. Two of them, exceptional ones, differ from the mean by one-third per cent., a few more by one-sixth per cent., but the greater number are within one-tenth per cent. of the constant used. Double weight was given the voltameter calibration, as involving less possibility of error than the other methods; with two exceptions, they are within one-fifteenth per cent. of the mean. Any error would enter directly.

(3.) Errors in the temperature correction of the fixed resistance.

The uncertainty due to the temperature correction of the fixed resistance must have been inappreciable. Its temperature coefficient was small, about one-tenth that of copper, while its temperature, considering the large surface of very thin metal exposed to the liquid, must have been quite accurately known. For the heavier currents, the oil was constantly stirred. With about 400 amperes in the circuit, the thermometer registered ·1deg. C. more when held against the strip than when in the body of the liquid, while the oil rose 1·5deg. during the test. To further decrease the possibility of error, the oil was kept within at the most 5deg. or 6deg. of the usual temperature of calibration by cooling it when necessary between the tests. An error would enter directly in the results.

(4.) Errors in the temperature correction of the resistance box.

Both ends of the box were open to the air and the coils were not coated with paraffin. The bulb of the thermometer lay against or very near the coil in use. The currents could cause no appreciable heating, and the temperature of the room changed slowly.

The temperature coefficient was taken as

·0004,

and calibrations made at different temperatures showed that this was not much in error. Errors would enter almost directly in the result.

(5.) Errors in the temperature correction of the galvanometer coils.

The temperature of the galvanometer coils was given by a thermometer hung near them. With the smallest resistance used, any error in this correction would only enter as one twenty-fifth in the result.

(6.) Errors in the values of the coils in the resistance box.

The measurement of the resistance box has been described. The values were probably correct within one part in 2,000 or 3,000. Any error would enter directly in the result.

(7.) Errors in the resistance of the galvanometer circuit.

The resistance of the galvanometer and its circuit was measured by the standardised bridge. The error was probably small and entered at the most as one twenty-fifth in the result.

(8.) Error in assuming the currents proportional to 2d.

This error is slight, and was to a large extent eliminated by making the calibration on about the same part of the scale as the measurements.

The only errors then that would be appreciable are in the deflections, the constant, the temperature correction of the box, and the values of the resistance coils. The last of these could hardly have been over one-twentieth per cent.; the temperature correction of the box was probably within one-tenth per cent.

This method has several advantages. The range is very great (with the apparatus described currents of from two or three amperes to 400 could be measured with about the same accuracy) while the errors are not multiplied in the result, and are of such a nature that with proper precautions many of them can be almost entirely eliminated, and the rest made very small.

Although in measurements of both potential and current any change in H would directly affect the results, yet as certainly two, and usually more, voltameter calibrations were made for each day of the tests, and the constants were checked after each measurement, it is not probable that any important error arose from this cause.

It is also interesting to note that the magnetometer records that showed such irregularities during the life tests of lamps* just finished, were remarkably uniform during the dynamo tests.

(To be continued.)

* *Journal* Franklin Institute, Sept., 1885.

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COMPANIES' MEETINGS.

The Eastern Telegraph Company (Limited).

The twenty-seventh half-yearly ordinary general meeting of the shareholders of this Company was held on the 21st inst. at the City Terminus Hotel under the presidency of John Pender, Esq.

The SECRETARY (Mr. G. Draper) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN, in moving the adoption of the report and accounts, stated that the revenue for the six months ended 30th September last had been £331,420, being an increase over the corresponding period of last year of £21,851. The chief increase in the traffic had been owing to the military operations in Egypt and Rangoon. The total working expenses had been £86,935, being an increase of £1,928. The working expenses at stations had been £60,497, being an increase of £2,488. They had opened new stations at Parliament street Westminster, and at Perim. There was also a full six months' working of Katacolo and Patras, against two months of the former and one month of the latter during the same period of 1884. There also had been an increase in the number of clerks at the stations where the pressure of business was greatest. Maintenance ships' reserve fund showed an increase of £2,000. The Directors, taking the view that the ships were tools for repairing their cables, had again decided to make a special provision for this fund. He reminded them that they were able to charge the cost of the "Volta" to this fund, and he hoped that the revenue would continue sufficiently good to enable them to reserve about £5,000 each half year, so that they could apply the total cost of their new ship "Mirror" in the same way. They would then have added two ships to their fleet without having increased the capital account. That matter was under consideration. As the shareholders were aware, the object of the Directors was to keep down the capital account. The expenses attending repairs and renewals and laying of cables had been £45,288, being an increase of £14,099. Full details of work done were given in "Abstract C." The ships had been constantly employed in the half year, and in addition to the important repairs effected, the "Volta" had laid a duplicate Chio-Syra cable, and had completed the final sections of the Greek cables, which entitled them to a prolongation for ten years of the subsidy granted by the Hellenic Government. There were also included the charter, outfit, and expense of cancelling the charter of the steamship "Ardmellie." That vessel was chartered at a time when the relations between this country and Russia were very much strained through the difficulties in Afghanistan. Had war broken out it would have been absolutely indispensable to have had their ship stationed at various points beyond Suez. When political affairs became settled they cancelled the charter of the "Ardmellie" and decided to buy a new ship to be on hand for emergencies. For similar reasons it was decided to increase their tank accommodation at Perim, Suez, Malta, Gibraltar, and Syra, and they could now store over 1,500 miles of cable should the necessity arise. That put the Company in a very efficient position for the maintenance of cables under any circumstances. They could, therefore, be useful to Her Majesty's Government in emergencies such as the laying of cable expeditiously along their route. The shareholders would be aware that their Company had, on several occasions, been of special service to Her Majesty's Government and to the commanders of our Army and Navy. They had transferred the Sardinian cable reserve to the general fund, which now amounted to £429,178, the sum total of the reserve being £444,875. They were able to pay a dividend with bonus at the rate of 6 per cent. per annum, and to carry forward £32,549, or £2,180 more than a year ago. Speaking of the Conference at Berlin last year the Chairman stated that he had been there with Sir James Anderson and several members of the staff. They had a very important part to play at the Conference from the fact that the submarine telegraph companies represented at that meeting about 100,000 miles of cable, costing about £35,000,000 sterling. The whole of the submarine cables belonging to the Powers of Europe represented 7,300 miles or £1,500,000. He might also say that the value of the submarine cables possessed by the different companies exceeded the cost of the whole of the land line system represented at the Conference. They had no vote at the Conference, however, and they had to show a good case if they desired to maintain their position. At the last Conference the great object of Germany was to get something like a universal rate established for submarine telegraphy on the Continent. The German Minster of Telegraphs and Posts had been successful in establishing a uniform postal system, and he thought it was possible to introduce the same system into telegraphy; but he found that that was a very different matter. The consequence was that while he had brought the other Powers to materially reduce the rates of Continental messages, and in reducing those rates had interfered with the Company's tariff in the Mediterranean, still, after all, at the end of the Conference, the Company found themselves in this position. Reductions were made to India, involving about £23,000, and in their Mediterranean system to the extent of about £17,000. Consequently the gross amount that they had to submit to in the way of reductions was about £40,000, a large sum, which, however, he believed would be shortly recouped with the improvement of trade and the stimulus which the reduced rates would give to telegraphy. He regretted that they had had no encouragement from the Press in fighting their battles at Berlin. At some length the Chairman then referred to the desire of the British Government to establish telegraphic communication between this country and the West Coast of Africa. The Government had invited tenders for that system, and, in conjunction with the Brazilian Submarine Company, the Eastern Company had applied for the tender, and had succeeded in getting the concession, the nature of which he detailed at length to the shareholders.

The VICE-CHAIRMAN (the Marquis of Tweeddale) seconded the motion.

The SOLICITOR then read the leading features of the agreement which had been entered into between the Government, the Company, and the Brazilian Company, relating to the proposed new submarine cable.

The motion was carried unanimously.

The retiring Directors, Lord Sackville Cecil and Lord Alfred Paget were afterwards re-elected, as were also the auditors, Mr. Henry Dever and Messrs. Quilter, Ball, and Co.

On the motion of the CHAIRMAN, seconded by the VICE-CHAIRMAN, the following resolution was subsequently carried unanimously:—

"That the Agreement submitted to this meeting, dated the 19th "January, 1886, and made between the Lords Commissioners of Her "Majesty's Treasury, of the one part, and the Eastern Telegraph Company "(Limited) and the Brazilian Submarine Telegraph Company (Limited), "of the other part, with reference to the establishment of submarine tele-"graphic communication between St. Vincent (Cape de Verde) and the "British possessions on the West Coast of Africa, be and is hereby "approved and confirmed, that the arrangements proposed by the Board "for transferring the said agreement to the African Telegraph Company "(Limited), and the subscription by this Company of a sum not exceed-"ing £75,000 to the share capital of that Company, and the raising of the "amount required for such subscription by the issue of £4 per Cent. "Debenture Stock of this Company, be also approved and adopted. And "that the Board be authorised to do all such things as they may deem "necessary or expedient on this Company's behalf to give effect to the "agreement and arrangements aforesaid."

A hearty vote of thanks to the Chairman and Directors terminated the proceedings.

[We shall publish a full report of this meeting in our next issue.]

The Brazilian Submarine Telegraph Company (Limited).

An extraordinary general meeting of the members of this Company was held at the City Terminus Hotel on the 21st inst., under the presidency of Lord Monck.

The SECRETARY (Mr. Richard Collett) read the notice covening the meeting, which was called to confirm an agreement between the Lords Commissioners of H.M. Treasury on the one part, and the Eastern Telegraph Company and the Brazilian Submarine Company on the other part, for the establishment of submarine telegraph lines between St. Vincent, (Cape de Verde), and certain British possessions on the West Coast of Africa, &c.

The SOLICITOR read the heads of the agreement, and stated that the new cable was to be laid by the 19th August next, or such extended time as the Government might think fit.

The CHAIRMAN then stated that they had been invited to attend that meeting in order that the Directors might obtain their sanction to the agreement which had just been read. It was virtually an extension of their system of telegraphy. The subject had only been brought before the shareholders within the last few days, but it had occupied the careful attention of some members of the Board for nearly three years. They understood some time in the year 1883 that it was the intention of the Government to connect the Settlements on the West Coast of Africa by telegraph with England, and as the most convenient, and, indeed, unless an independent line of telegraph were made, the only way of communicating with them was through the Company's system, they were of course deeply interested in seeing that no strangers got hold of the new communications. They had been in continual communication with the Government for over a year on the subject, and it was referred to a committee of the Board to conduct the negotiations in connection with members of the Eastern Company's Board. They would see the reason of that when he reminded them that the Eastern Company's cables constituted a portion of this Company's system, and the Eastern Company were therefore equally interested with themselves in securing the telegraph communications to West Africa. After a great deal of negotiations, about two months or six weeks ago they came to an agreement with the Government under which the Government would give a subsidy of £19,000 a year for 20 years to complete the communication between this Company's system at St. Vincent with Bathurst and the different British settlements southward to the Niger and the Cameroons. Having completed that arrangement they considered the best mode of carrying the object into effect, and they came to the conclusion, in concurrence with their allies, the Eastern Company, that the best and most convenient mode of doing it would be to start a new company, in which they should hold the shares. It was, therefore, proposed that the Eastern Company, the Brazilian Company, and the Telegraph Construction and Maintenance Company, who had also joined them, should hold the shares, but that it should be an independent company, because no one of the three allies commanded the whole line, and could not therefore work it without introducing into the management of their own concern an independent partner, which would not be convenient. All the traffic was to be conducted through the Brazilian Company's office, and their Managing Director was to be Managing Director of the new line. The Brazilian Company would have the whole of the traffic which proceeded from England over their lines to St. Vincent, and one-third of the net proceeds of all messages from St. Vincent to the West Coast of Africa. As to the financial part of the arrangement, they had thought it the best course that the Company, the Eastern Company, and the Telegraph Construction and Maintenance Company should provide the share capital of the new company by means of debentures, the three companies each providing in that way a third of the share capital. It was proposed that the balance of the cost which might be required for the new cable beyond

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the share capital subscribed by the three companies should be found by the new company raising debentures of their own. The share which each of the three companies would subscribe would be about £75,000. He thought this would be a very good financial arrangement, and it was very advantageous that they should have the control of the line, so that they might not run any risk of any competitor intervening between them. It was thought when they proposed to duplicate their cable they would have to raise about £250,000 by debentures to do so; but they had succeeded in carrying out that work, and had only raised £150,000. Therefore, after paying for their share in the new cable to the West Coast of Africa, they would be £25,000 better off than they expected to be after duplicating their original system. He concluded by moving a resolution, in effect, approving of the agreement.

Sir JAMES ANDERSON seconded the motion, and stated that at first he had taken a rather gloomy view of the prospects of trade on the West Coast, but subsequent inquiries of his had caused him to take a more sanguine one. There had been a great deal of talk during their negotiations about their going on to the Cape of Good Hope with an alternative line, but he did not think our Government or the Cape Government were at all disposed at present to assist in that.

A short discussion followed in which Mr. Griffiths, Mr. Barham, and Mr. Blewitt took part.

The CHAIRMAN stated that the Eastern and Brazilian Companies were the only parties to the agreement with the Government. The Telegraph Construction and Maintenance Company were not a party to it. He had omitted to state in his opening remarks the length of line, which was 3,117 miles. The capital required for laying the cable was expected to be £460,000, of which £250,000 would be provided by debentures of the new company, and the balance, £210,000, in shares. The debentures which this Company proposed to issue would be irredeemable for twenty years, carrying 5 per cent., and would be offered to the shareholders first. He could not agree with Mr. Barham that their liabilities were very onerous.

After replying to a few more questions, he put the resolution, which was carried unanimously.

On the motion of Mr. BARHAM, seconded by Mr. G. ANDREWS, a vote of thanks to the Chairman was passed, and the proceedings terminated.

The Western and Brazilian Telegraph Company (Limited).

The thirteenth ordinary general meeting of the shareholders of this Company was held at the Cannon-street Hotel yesterday, under the presidency of Mr. W. S. Andrews.

The SECRETARY (Mr. R. M. Cunningham) read the notice convening the meeting, and the minutes of the last meeting. The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said that in the absence of Sir Henry Drummond Wolff, who was abroad on a foreign mission of considerable importance, the Directors decided to rotate the chair, so to speak, among themselves, and it was owing to that circumstance that he was in it on the present occasion. The duty that he had to perform, however, was not altogether a disagreeable one, because he had to draw their attention to a more satisfactory state of things, he was very pleased to say, than it had been their fortune to experience for some time. They would all, no doubt, have noted that the revenue for the year ended September, 1885, did not alone show a great increase over the income of the present year, and of the year before that, but was, in fact, the largest amount that the Company had ever earned since it began business. For instance, if they took the year 1883 (and he took it, because in 1884 there was an abnormal state of things owing to an interruption for an extended period of the cables of the Brazilian Cable Company), they found that, as compared with 1883, on the 1st of September of which year the reduction of tariff came into operation, there was an increase of 12 per cent. shown; and if they took the year 1884 there was an increase in money of £21,222, and of no less than 20 per cent. Although these figures were exceedingly encouraging, they did at one time anticipate that they should have had a still better statement to lay before them, and they could have done so but for a circumstance that was entirely beyond their control, namely, an adverse condition of the exchange at Brazil. They might have noticed, that owing to the state of the exchange, the revenue of the Company had suffered to the extent of upwards of £10,000. Of course, they would be delighted if they could devise any scheme by which that serious loss could be stopped, but, unfortunately for the present, there was, he was afrraid, no remedy, nor any immediate prospect of it, for that state of things. At one time the Company was making a profit on exchange. Therefore, let them hope they might reach a period when they would make a profit on it again. This year he could only say that they would have been another £10,648 to the good if it had not been for the unfavourable rate of exchange. Having touched upon the revenue, which he thought they would all feel was a very gratifying one, he would pass on to the expenses. They had earned 20 per cent. more money, not only without any addition to the working expenses of the Company, but with an actual diminution in them of £1,700. The total expenditure was £7,142, but of that sum no less than £1,500 would not appear in the accounts again, something like that amount having been spent last year to meet very exceptional charges. It was rather an invidious thing to do, but their acccounts had been compared with those of the Brazilian Submarine Company, and in one case a gentleman, who had compared them, and who was not sufficiently acquainted with the facts, seemed to have fallen into the very natural error of supposing that their business was more expensively conducted than that of the Brazilian Submarine, whereas the direct reverse of this was the case, their own business being much more economically conducted. The Brazilian Submarine Company had four stations altogether. One was in Portugal, one in Madeira, which might practically be said to be in Europe, one in St. Vincent, which was approximately European in point of expense, and only one was in South America. Now the whole of theirs, twelve in number, were in South America. They had the whole of the business to collect; they had all the counter work at every one of those towns in South America, and consequently they had expenses which practically did not exist in the case of the Brazilian Submarine. Then, in addition to that, they had the expense of the repairing ships, with all their stores, &c. They would imagine that under these circumstances their stations would be more expensive than those of the Brazilian Submarine Company, but the latter averaged per annum a cost of £4,000, while those belonging to this Company averaged a cost of £1,800. He thought that that comparison, looking at the amount of extra work done by them, and the more costly character of their service altogether, was a very satisfactory one to the shareholders of the Western and Brazilian Company. The London expenses of the Brazilian Submarine Company were £7,125, and those of the Western and Brazilian Company £6,933. Therefore, although there was a great deal more work in their London office, there was actually a less expenditure of £192 than there was in connection with the Brazilian submarine. It was not much, he admitted, but it was very satisfactory. There were some gentlemen present who had not been in the Company from its origin, and who were unacquainted with the condition of things that existed when the present Board took office. Then they had, so to say, a spinal cord 3,700 miles long, and of those 3,700 miles 2,700 were diseased. Then they had the old unsuitable type of strand cable. The effect of that was that they were under the necessity of keeping their ships upon the spot. It was the cause of constant breakages to their lines, of imperfect working, and of small revenues. The present directors were brought in as doctors to cure that state of matters if they could. But they had not the Bank of England at their back, and they had to proceed with caution and by degrees. But he might say that their system had been improving by degrees as their work had gone on by degrees, until at present they had reached a very satisfactory position, and could really see the end of their trouble. They had renewed of that bad stuff, extending to 2,700 miles in length, no less than 85 per cent. It had been accomplished gradually under the encouraging aid which the shareholders had given to the Directors. Unless the shareholders had had confidence in them, and supported them by their willingness to forego dividends, the work of renewal could not have been accomplished. The remainder of the cable that has still to be renewed extended to about 400 miles. Perhaps some of it was being renewed now, because the ship was out on the spot with the object of substituting a new cable for the old one, from Bahia in the south—some 200 miles—and then she would probably finish the other 200 miles that remained between Pernambuco and Ceara. Then they would have a good spinal cord from one end of their system to the other. The Directors had frequently considered the question of the ships. The strand cables and the ships went very much together, though not entirely. They must always have the ships, because they had a great many shore ends, and they had nearly 4,000 miles of cable, but the Board thought that they could do with a different class of ship, and they could therefore see their way to diminish their expenses very considerably under that head. There was, in point of fact, even this year as compared with last, which they would probably have noticed, a saving in the shipping of some £950. That might be taken as an indication that the Directors did their best to keep down the expenditure. The outcome of the legacy that was left to them would be in a year or two represented by a sheath cable all the way. Of course they could not have done the work without something in addition to the aid the shareholders gave them, and that was the renewal fund, which came in just at the nick of time, and he would say a word as to the necessity of the renewal fund. He hoped the shareholders would always back up the Board with regard to it. The boards of companies, as a rule, never wanted to put by more than was really necessary, because they were only too glad to give a dividend to the shareholders if they could. He might say that in ninety-nine cases out of a hundred Directors did not recommend the putting of more to reserve than was absolutely necessary. Certain exchanges of ideas had taken place between the Company and the authorities of Brazil and other parties interested in cable communication between this country and South America with the view of coming to some sort of working arrangement. But as yet there were no positive propositions before them. The interests were exceedingly complicated, and if any arrangement came out of the negotiations—which they must not understand him to say that he believed would be the case—it would be exceedingly difficult to bring about. Therefore, his impression was that, under the circumstances, discussion on the subject would be inadvisable. He thought they would be satisfied, when the result of those negotiations was made known, that the Directors had done the best they could for the Company. Some of the shareholders—very influential gentlemen, too—were at one time disposed to think that there was a committee named to assist the Directors in case those negotiations proceeded. They communicated with the Board in the most courteous spirit. The Directors replied, he hoped, in the same spirit, and the conclusion come to was that it was inadvisable as a matter of principle to increase the number of negotiators. He thought they had always a better chance of coming out successfully with a practical result from negotiations the fewer people there were on such committees. If they had twenty men, for example, there were pretty sure to be, more or less, twenty conflicting opinions to deal with. To sum up, their present position was—a nearly completed metal-covered cable the whole distance; the probability of lessened expenses; the certainty of a largely increased revenue which they now put before the shareholders; and the further certainty of the declaration of a dividend of 2½ per cent. if the shareholders chose to vote it. He concluded by formally moving the adoption of the report and balance-sheet.

Major WOOD seconded the motion.

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A protracted discussion then ensued upon the accounts, in which Messrs. Guesdon, Swinton, Sutton, Major Cotton, Herring, Griffiths, Pyke, and others took part.

The CHAIRMAN, in replying to the various questions addressed to him, said that he need scarcely point out that the Directors in their position as the representatives of the shareholders could do nothing to commit the shareholders to the terms of any agreement without not only consulting them, but submitting the whole of the terms to them, and being ruled by their decision. All that the Board could do was to recommend to them a particular course of action. Whether they should recommend that particular course of action to a particular section, instead of to all the proprietary, was quite another question. He thought they must deal with the shareholders in a body, and not in sections, for obvious reasons. As to the item bills receivable, £26,172, that was the remittances for traffic. With regard to the expense of the insurance of the "Norseman," that was unavoidable. Travelling expenses represented the sending out and bringing home of members of the staff. It was a necessary expenditure, and could not possibly be obviated. Its amount depended upon the appointment and the removal of clerks to different places. The other item of travelling expenses was occasioned by the conference at Berlin, at which the Company had to be represented. That was an item which of course would not appear again. Their auditor (Mr. Weise) was a member of the firm of Messrs. Turquand, Youngs, and Co., a thoroughly competent accountant. A question had been very properly asked by Mr. Guesdon with respect to the repairs that had been made in their system to get rid of the old cable, and that was whether they had gone about it by the process of tender. They had done so, and they had been enabled to accept the lowest tender. There were two items of insurance. One was on account of the clerks engaged abroad, and the other for the benefit of those who were engaged in London, and the Directors, in order that the shareholders might clearly see how their money was spent, divided the item into two parts, so that they could see under which head the different amounts stood. With respect to the "Viking," she originally stood at £19,000, but they would see that she had been gradually reduced to £16,000. As regarded the negotiations he had referred to, they had been very prolonged. Very little was known about them, and the fact was that if they had from time to time communicated the character of those negotiations to the shareholders, they would simply have been utterly misled. They would have been led to expect things that would never have come to pass, and to anticipate conclusions that never would have been arrived at. But when he told them that in Brazil, during the comparatively limited period during which the negotiations had been pending, there had been six changes of the Ministry, they would at once appreciate the fact that they had to deal with a Government of a somewhat camelion like character. It had been no fault of the Directors that the negotiations had been delayed. There had been some adverse comments made as to the expenses of the administration. He could only again repeat what he had already said, that of the £7,100 there was some £1,500 of an entirely exceptional character, which would not appear in the accounts again. One gentleman regretted that they did not give a larger dividend, and another objected to the Directors' fees, which he characterised as excessive. Well, he (the Chairman) could not agree with them, for the very simple reason that the gentlemen on the Board had nothing whatever to do with the inception or with the carrying out of the business of the Company. They had had to deal with a state of things which the shareholders appeared originally to have approved, and which bore within them the very seeds of disaster. In fact, if they had not had the present Board to undo the mischief of their predecessors, he thought the probability was that the Company would have ended its transactions in a very disagreeable place. He had shown them as well as he could what the present Directors had done for them, what were the means at their disposal, and the difficulties they had had to labour under, and he thought that the outcome, namely, that they had a sound, healthy undertaking, instead of the very imperfect system they had before, was not altogether discreditable to the present Board. He was a man of business, and he did not, of course, assist in administering their affairs simply out of pure love of administration. He did so because they paid him for it, and they seemed to be satisfied with his work, and he hoped their connection might continue and be equally satisfactory to them all. As to the question of proxies, he thought they were very necessary, for the simple reason that it was only by the proxy system that the shareholders could be properly represented. It could easily be shown how inconvenient and disastrous it would be to companies if there were no such plan of getting the views of shareholders. In further reply to Mr. Guesdon, the Chairman said that Sir Henry Drummond Wolff was still a Director of the Company and took his fees, which were divided among the five members of the Board.

The SOLICITOR pointed out that the remuneration and number of the Directors were fixed by the Articles of Association, and that they could be altered only by a resolution passed and confirmed at two special meetings of the shareholders.

The CHAIRMAN, in further reply to a shareholder, said that they paid a fifth of the gross receipts in Brazil to the Platino Company.

The motion was then put to the meeting and carried unanimously.

The CHAIRMAN next moved, in accordance with the recommendation of the Board, a dividend at the rate of 2¾ per cent. free of income-tax.

Mr. D. H. GOODSALL seconded the motion, which was agreed to *nem. con.*

Major WOOD then took the chair, and in a few eulogistic remarks proposed the re-election of Mr. Andrews as a Director of the Company.

Mr. SUTTON seconded the motion, which was carried unanimously.

Subsequently Mr. Goodsall was, on the motion of the CHAIRMAN, seconded by Major WOOD, re-elected to his seat at the Board, and the auditor having been reappointed, a vote of thanks was accorded to Mr. Andrews for presiding, and the proceedings terminated.

Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of this Company was held at the Cannon-street Hotel on the 15th inst., under the presidency of Mr. Hugh Watt, M.P., to consider the following resolutions :—

"That the capital of the Company be reduced by £62,500 by cancelling paid-up capital unrepresented by available assets (being patents overestimated in value) to the extent of 5s. per share upon each of the 250,000 shares which have been issued and are now outstanding."

"That the capital of the Company be further reduced by £62,500 by reducing the nominal amount of the remaining 250,000 shares of the Company's capital from 10s. to 5s. each, thereby leaving the nominal capital of the Company £125,000, divided into 500,000 shares of 5s. each."

The ACTING-SECRETARY (Mr. John Wright) having read the notice convening the meeting,

The CHAIRMAN proposed the first resolution, as above. He stated that all the old shareholders would be aware that the Company was floated under the name of the Electric Light and Power Generator Company, and that the patents for which it was formed and floated were the Rapieff, the Lontin, and the Harding. Of the value of those patents the shareholders were probably as cognisant as he. Afterwards the Directorate in conjunction, if he were not mistaken, with the promoter entered into an arrangement with the United States Electric Company or their representatives to purchase the Maxim-Weston patents. The result of those negotiations was, no doubt, to some extent, eminently satisfactory, as by the acquisition of those patents they had been placed in a position to carry on a legitimate business, for the patents which the Company had been formed to work were simply unworkable. Having, however, paid between £50,000 and £60,000 for the Maxim-Weston patents, he thought that provision ought to have been made by which the Company could obtain in the future plant from the United States Company at a much less cost than ordinary purchasers. He was glad to state that the management of that company in America had met him so far in a very handsome way, on the representations which he had made to them. On the working of the previous twenty-one months they showed a handsome profit, and for the past year they would show, when the accounts were audited and presented, a good profit, enabling them to declare a dividend in the event of the proposed resolutions being agreed to. That was one of the reasons which had led the Directors to bring the proposed resolutions before the shareholders. During the past year the working purposes of the Company had necessitated the issue of 50,000 shares, which the proprietors sanctioned in May, 1884. That capital had been placed, the limit given to the Directors being 5s. per share. There was consequently a large deficit, and he was advised by their solicitor and counsel that it would be impossible to declare a dividend until the capital had been reduced to the price of issue. Two years and nine months ago they sanctioned the issue of 27,500 shares at 5s., and the old shareholders thought that was no inducement to them, even at that price, to save their property, and his colleagues and self were forced to supply the capital. He had been very much pressed during the last year by letters from shareholders who desired a dividend, and if the Directors could have declared one without "cutting" the capital he would not have troubled the shareholders that day. It had, however, been decided by the High Court of Justice that a dividend could not be declared unless the capital were intact. The shareholders had twice sanctioned the issue of shares at 5s. each, and, of course, the Directors would not have issued above capital had it been possible for them to go on without it. All the working capital they had, however, after paying the debts of the old Company, was £2,500; and he thought they must agree with him that in view of the contracts taken, and in prospect, it was impossible for a company like theirs to go on with a capital of £2,500, competing, as they did, with companies who could make a call of 5s. or 10s. when they thought necessary, and with private firms who had come into the competition unsaddled by patents at all. Some of the old original patents had expired, and therefore, during the past year, while they had done considerably more business than in the previous year, they had probably not made a larger profit, as they had had to meet the market in price. Possibly the policy of the Board might have been somewhat fallacious, but it had been to some extent dictated by the fact that they had a large dead capital, about £175,000 having totally gone. The Directors did not wish to press the resolutions if the shareholders did not desire a dividend ; but, after all, the reduction of capital would be effected by writing down the value of the patents. He contended that the change would not affect the intrinsic value of their property, though he would not say that it would not affect its market price. The Directors had no wish to depreciate the market value of the shares, in which they were largely interested ; on the contrary, he would like to see them at a fair price; but he had arrived at the conclusion that the market value of a stock was frequently in inverse ratio to its intrinsic merits. The Directors had not been able to do all the business they could have wished in the past year, but they had done all they could to promote the interests of the Company, which he believed would in future go on steadily progressing. He concluded by moving the resolution, repeating that it was necessary it should be passed if the shareholders desired a dividend for last year.

Mr. SWABY, in seconding the motion, observed that there might be some shareholders who had joined the Company recently, and who were not very conversant with either the past or present position of the Company. He thought it very reasonable that the new shareholders might say "Why should the Directors wish to write off half the capital ?" and they might ask, equally, what the Directors had done with the half which they desired to write off. The question was very easily answered. The Directors had done nothing with the other half of the capital, as they had never had it to do anything with. If he could have his way he would go further than was now proposed. He would not only reduce the

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shares to 5s., but would afterwards convert them again into £1 shares by exchanging four shares of 5s. for one share of £1, making the capital paid up £62,500 in shares of £1 instead of £62,500 in 250,000 shares of 5s. each. That, however, was only a suggestion of his, and it entirely rested with the shareholders to do what they pleased with it.

Mr. THOMAS said he feared the process of reconstruction would go on again if the suggested conversion were made, and the 5s. shares turned into others of £1. He considered that it would be to the interest of the shareholders not to reduce the capital for the mere sake of a dividend, and that if the exigencies of the business required it, they should push the business forward by means of the profit made, the shareholders waiting for a dividend. On the 31st of March, 1883, the patents were valued at £113.819.

The CHAIRMAN remarked that over £130,000 was the sum first paid for them by the late Board.

Mr. THOMAS, continuing, stated that in March, 1884, they were reduced to £70,000. That was a writing off £43,967 then for depreciation of the patents. He afterwards alluded to the remarks made by the Chairman at former meetings, and said that if there was any value in the opinions so uttered, as lately as nine months ago, he (Mr. Thomas) could not see where the value of the patents had disappeared.

Mr. GRIFFITH said he did not think it was correct to say that a dividend could not be paid when the capital had fallen below its original value. He mentioned instances of companies where the original capital was below its value—taking the value of the Stock Exchange—and stated that dividends were regularly paid by them. Putting aside this view of the matter, however, there were other objections to the resolutions. They had already reduced the shares from £1 to 10s. each. He had been glad to hear that the business of the Company had been so good that a profit had been made, but unfortunately they had not the balance-sheet for the past year before them, or they could see the exact position they were in. Supposing the resolution were wise it seemed premature to pass it until they had seen the accounts. He was opposed to it altogether.

Mr. RUSSELL thought that the shareholders must feel grateful to the Chairman and Directors for what they had done to promote the welfare of the Company, but he really thought it would be better to postpone the resolutions until the shareholders had been presented with the accounts for the past year, and he therefore proposed an amendment to that effect.

Mr. GRIFFITH said he would second the amendment.

The CHAIRMAN said that with all due deference to Mr. Griffith's professional opinion, he had been advised, and from having examined the judgments which had been delivered he asserted, that no dividend could be declared by a Company in their position without personal liability attaching to the Directors. It was of no use maintaining their patents at a fictitious sum. He did not go from the remarks he made nine months ago, but he quite agreed that the hopes he then held out had not been fully realised. At that time companies were drifting into liquidation, and the prospects were that the Maxim-Weston, with a few others, would remain alone in the field. By other companies going into liquidation, however, thousands of dynamos had been thrown on the market, and the result had been of necessity to lower the price of the plant of the Company.

Mr. JOHN NEWTON said that he had become a shareholder, although he knew nothing about the Company, but when he heard that a proposal was to be made to reduce their shares to a sum which would represent their capital he immediately bought ten shares. He had devoted the last seven years of his life to studying the question of paying dividends out of capital; and he maintained that a company could not legally pay a dividend unless their assets represented their capital. He supported the proposed reduction, and expressed his belief that the price of the shares would advance on the payment of a dividend.

Mr. THOMAS said he objected altogether to the payment of a dividend in the present condition of the Company.

Mr. GRIFFITH said it was true that outside creditors could come against Directors who paid a dividend out of capital; but the Chairman had stated that upon the trading of the last twelve months a dividend had been truly earned. He still kept to his opinion that the shareholders had the power to accept a dividend, and that there would be no danger to the Directors in paying it, but that was on the supposition that the Company had no outside creditors whose debts were unpaid.

The CHAIRMAN stated that on the 31st of December last the Company had about £12,000 cash at the bank, and some £12,000 was owing to them, about one-third of that amount being due from the British or Colonial Governments. On the other hand, the Company owed perhaps as little as £300 or £400, he could not say exactly. He believed that Mr. Griffith's view was correct, provided that every shareholder agreed to accept the dividend, and passed the resolution; but one dissentient shareholder could take exception to the whole proceeding, and render the directors liable for the amount paid.

A SHAREHOLDER expressed his belief that the Company would be damaged unless the shareholders agreed with the course proposed by the Directors. In his opinion it was merely writing off a nominal sum.

The CHAIRMAN repeated that they were not affecting the intrinsic value of the property. He only asked them to reduce to £35,000 the sum of £85,000 now standing to the debit of patents. As to adjourning the meeting, at that time there was a good deal of work on hand, and he thought the Directors could devote their energies to better purpose in the interests of the Company than to hold an adjourned meeting. He was very desirous that they should come to a decision that day. As to the remarks made about the declaration of a dividend, he would remind the meeting hat there were some who had invested their all in the Company, and to whom a dividend would be of great importance. There was no doubt that if they distributed, say, £3,000 to £4,000 in dividends they would have so much less in hand to work with, but he intended to propose—so as to prevent the possibility of paying too much away—that they should pass not less than £2,000 to reserve fund. In reply to further questions, he stated that they had greatly improved on the Maxim and Weston patents. If the resolution were not passed, it would virtually mean no dividend for two years. There was no power at present to issue any more shares, but possibly at the general meeting he might ask them to authorise the Directors to issue, as and when required, a further 50,000 shares. If so, however, it would be in connection with a matter which would place the Company on a very different footing.

Mr. RUSSELL eventually withdrew his amendment, and

The CHAIRMAN then put the original motion, which was carried. Continuing, he proposed the second resolution.

Mr. JOHN BROWN (a Director) seconded the motion, which was carried.

On the motion of Mr. GRIFFITH, seconded by Mr. RUSSELL, a vote of thanks was passed to the Chairman, and the proceedings then terminated.

LEGAL.

Oliver v. British Telephone Company.

On Monday last, at the Southwark County Court, Judge Holroyd and a jury were engaged in hearing a case in which Mr. William Wilcocks Oliver sued Mr. George Driver, manager of the British Telephone Company, and Messrs. Burt, Boulton, and Haywood, contractors, for £50 for wilful trespass upon the roof of plaintiff's premises, 15, Dockhead, Southwark, and placing thereon in 1881 telephone poles and wires without his knowledge or consent, and in so doing injuring the premises. Mr. Overend appeared for the plaintiff, and Mr. Spokes for the defendant.

The plaintiff, in the course of his examination, stated that his roof was very much injured, and he could not let the upper part of his premises for nearly four years, when he found that the defendants had caused the mischief through the General Post Office.

The defendants practically admitted their trespass, and paid £9 into court, and evidence was given on both sides as to the extent of the plaintiff's loss.

In the end the jury found a verdict for £20, inclusive of the sum paid into court.—Costs were allowed.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Jan. 20.		Business Done Week Ending Jan. 20. Highest.	Lowest.
Anglo-American	32,	33	32⅝	32
Do. Preferred	55,	56	57	55⅝
Do. Deferred	9½,	10¼	10⅜	9⅝
Brazilian Submarine	10⅝,	10⅞	10 13-16	10 11-16
Cuba	10¾,	11¼	11¼	10¾
Do. Preference	17½,	18½	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9,	9½	9⅛	—
Eastern Telegraph	11⅝,	11⅞	11⅞	11⅝
Do. 6 per Cent. Preference	13½,	13¾	13⅝	13¼
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	12¾,	13	13	12 13-16
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 3-16	7
Do. Preference	13¼,	13¾	13¾	13 9-16
Great Northern	14½,	15	14⅞	14½
Indo-European	32½,	33½	33¼	—
Reuter's	7,	7½	—	—
Submarine	200,	210	209	206¼
West India and Panama	⅝,	⅞	¾	—
Do. 1st Preference	8¼,	8¾	8½	8⅜
Western Brazilian	6¾,	7	7	6 11-16
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Companies.	Closing Prices. Jan. 20.		Highest.	Lowest.
Consolid. Telephone and Maintenance	15-16,	1 1-16	1	—
Oriental	3-16,	5-16	—	—
United Telephone	12,	12½	12 11-16	12¼

ELECTRIC LIGHT.

Companies.	Closing Prices. Jan. 20.		Highest.	Lowest.
Anglo-American Brush Light (£7 paid)	3¼,	3½	3⅜	3¼
Do (fully paid)	5¼,	5¾	—	—
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1⅜,	1⅝	1⅜	—
Maxim-Weston	¼,	⅜	⅜	—

MISCELLANEOUS.

Companies.	Closing Prices. Jan. 20.		Highest.	Lowest.
Telegraph Construction	36½,	37½	37⅜	37
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24½	24¼

TRAFFIC RECEIPTS FOR DECEMBER, 1885.

Companies.	Dec., 1885.	Dec., 1884.	Increase.	Decrease.
Cuba Submarine	2,450	2,553	—	103
Direct Spanish Telegraph	1,754	1,748	6	—
Eastern Extension	34,785	41,426	—	6,641
Eastern Telegraph	53,179	53,036	143	—
Great Northern	20,280	—	—	—
West Coast of America	3,825	—	—	—

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NOTES.

QUEENSLAND.—This colony has £250,000 to spend on telegraphs.

THE LATE STORMS.—The American telegraph system seems to have suffered severely from the late storms.

THE CENTRAL STATION AT TOURS.—We hear that the central electric lighting station at Tours has been formally inaugurated.

THE AMERICAN TELEGRAPHS.—Advices from Philadelphia state that telegraphic communication with San Francisco has been resumed.

THE STRAITS SETTLEMENTS.—Advices from the Straits Settlements state that a telegraphic line has been opened from Hue to Tourane.

THE TELEPHONE IN FRANCE.—It is announced that the telephonic service between Rouen, Elbeuf, and Louviers will be opened on the 1st proximo.

THE ELECTRIC LIGHTING ACT.—Mr. Stanhope will shortly bring in a Bill to amend the Electric Lighting Act. Mr. Hugh Watt also notifies similar action.

PERSONAL.—The Khedive has conferred the rank of Bey upon Mr. Charles Clarke, C.M.B., in recognition of his services in the Egyptian Telegraph Department.

TELEGRAPH MATERIAL FOR CHINA.—During the year 1884 telegraph wire and apparatus of British manufacture to the amount of £33,296 was exported to China.

A NEW LAMP.—It is said that the Actiengesellschaft für Feilenfabrication of Berlin are about to bring out a new incandescent lamp, to be called the "Berlinoise."

AN INTERESTING PAPER.—On the 20th proximo M. Pellat will read a paper before the Association Scientifique de France upon "Electric Machines Past and Present."

IN THE EAST.—A telegram from Constantinople, dated January 20th, announces that telegraphic communication between Philippopolis and Andrianople will be re-established in a few days.

THE QUADRUPLEX TELEGRAPH.—The American Commissioner of Patents has recently decided that the first and original inventor of the quadruplex telegraph is not Edison, but Dr. Henry C. Nicholson.

THE INDIAN TELEGRAPHS.—The telegraph service of India included in 1883, 21,740 miles of line, 62,830 miles of wire, 130 miles of cable, 324 offices, with 1,810,906 messages, yielding a revenue of £545,315.

TELEGRAPH MATERIAL FOR THE CAUCASUS.—A telegram from St. Petersburg, dated Jan. 23, says it is announced to-day that orders were recently given for the formation of a second depot of military telegraph material in the Caucasus.

REPAIRING CARBON FILAMENTS. — Our contemporary, *Electricité*, announces that an electrician of the firm of Ganz and Co. has discovered a means of repairing the carbons broken in incandescent lamps and rendering them fit for service.

ELECTRIC LIGHTING OF A MANSION.—Burtonhill, Malmesbury, the residence of Col. Miles, M.P., is to be lighted by the electric light; about 150 lamps will be employed. The work has been entrusted to Messrs. A. R. Sennett and Co.

THE LIGHTING OF TAUNTON.—The Taunton Electric Lighting Company has been formed for the purpose of lighting the town according to the Thomson-Houston system, and the provisional directors have commenced canvassing the town for consumers.

A LECTURER'S SCALE.—The current issue of *L'Electricien* contains an account of a galvanometer scale specially devised for lecturing purposes. There are two forms of this scale, one transparent and the other opaque. But few points of novelty are, however, presented.

OPTHALMOLOGICAL SOCIETY OF THE UNITED KINGDOM.—On Thursday last the following papers were read before the members of this society:—Dr. Thomas Reid: "Opthalmoscopes adapted for Electric Light;" Mr. H. Juler: "Refraction Opthalmoscope arranged for the Electric Light."

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 22nd inst. amounted to £3,087. The Company give notice that the coupons on their Five per Cent. Debentures, due 30th inst., will be paid on and after that date at the Alliance Bank.

GRAVET'S SLIDE RULE.—We are informed that this rule has during the past year found a large sale amongst the electrical world and in the science and technical schools and classes. The authorities at South Kensington have adopted it generally throughout their classes, and now recommend its use to all engineering and electrical students.

THE ROYAL VISIT TO CHESTER.—On the occasion of the recent visit of H.R.H. the Prince of Wales to Chester, Eaton Hall, the residence of his Grace the Duke of Westminster, whose guest the Prince was, was lighted by the Electrical Power Storage Company, who sent E.P.S. accumulators fully charged from their works at Millwall.

PROPOSED CABLE BETWEEN AMERICA AND AUSTRALIA.—A telegram from New York, dated January 25th, states that two gentlemen from Australia, one of whom has already arrived at San Francisco, and the other is on the way, will shortly proceed to England with the object of promoting the scheme for laying a telegraphic cable between San Francisco and Australia.

THE BROOMHILL OBSERVATORY.—A provincial contemporary says:—"A most conspicuous object for many miles around Southborough is now the new electric light, equal to 15,000 candle-power, which Sir David Salomons has lately erected on the summit of his lofty astronomical observatory tower. Its effects over the snow-covered country last week were specially brilliant and vivid."

AMERICAN STATISTICS.—According to the quarterly report of the Chief of the Bureau of Statistics, Treasury Department, relative to the imports, exports &c., of the United States, for the three months ending 30th September, 1885, it appears that the exports of instruments and apparatus for scientific purposes, including telephone, telegraph, and other electric material, amounted to $88,635 as against $102,348 for the corresponding period in 1884.

THE BEST PROTECTION.—The tomb of the late Mr. H. Vanderbilt, at New Dorp, Staten Island, is guarded night and day by a corps of detectives. The niche in the vault in which the coffin of the dead millioniare is placed is connected with an electric alarm, and even if a tunnel could be driven to the tomb, any attempt to remove the body, or any tampering with the wires of the alarm, would be made known immediately at the head-quarters of the guards.

THE INVENTION OF THE SPEAKING TELEPHONE.—Our American namesake is of opinion that the Meucci story is simply a new version of the Drawbaugh claim, and one which cannot fairly be said to be in any respect more credible than that.

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As regards the contest in the Patent Office between Eccard and Drawbaugh, to determine the question of priority of invention of a certain form of telephone in use in the Signal office, the examiner has decided Drawbaugh to be the prior inventor.

The Institution of Civil Engineers.—There will be a students' meeting on Friday, January 29th, at 7:30 p.m., when a paper will be read on "Electrical Measuring Instruments," by Llewelyn B. Atkinson, Stud.I.C.E., Dr. John Hopkinson, F.R.S., M.I.C.E., in the chair. An ordinary meeting will be held on Tuesday, February 2nd, at 8 p.m., when the paper to be further discussed will be "The Injurious Effect of a Blue Heat on Steel and Iron," by C. E. Stromeyer, Assoc M.I.C.E.

Another Coincidence.—Messrs. Duff and Rowntree, write to inform us that, having regard to our note of the 8th instant relative to the introduction of the electric light into Singapore by Mr. Wells, who introduced gas into the same colony about twenty-four years previously, their electric light plant is situated within a few feet of the first gasometer put down in Bishop Auckland some fifty years ago, and that the grandson of the person who put in the gas apparatus has now charge of the electric lighting machinery.

Painful Accident.—An unfortunate accident occurred recently at Messrs. Rollo's engineering works, Liverpool. Christopher Edwards, who had charge of the electrical apparatus with which the place is fitted, had just replaced the carbon burner, when a lamp fell upon him. He was picked up insensible and taken to the hospital, when it was found he had lost his eyesight. A fellow workman dreamt the night before that Edwards was handing him a battery, when it knocked him down, and he was carried away insensible.

The American Patent System.—The author of an article upon the American patent system has come to the conclusion that the money derived from patent fees ought to be expended in furtherance of the patent system. As it is, whatever is collected in the way of fees is covered into the common treasury of the Government, and whatever is expended is grudgingly appropriated by Congress. The result is a handsome balance to the credit of the Patent Office, but the plan is greatly opposed to the best interests of the patent system and to inventors in general.

A Complimentary Dinner.—We hear that Edinburgh intends to entertain the Right Hon. J. H. A. Macdonald, Q.C., LL.D., M.P., Lord Advocate of Scotland and a distinguished Associate of the Society of Telegraph-Engineers and Electricians, at dinner on the 6th proximo. Mr. Macdonald, it will be remembered, is the inventor of the "Holophote Course Indicator," and has received medals at the Crystal Palace Electrical Exhibition, and at the Inventions Exhibition, as well as an honourable mention at the Exhibition of Appliances for Saving Life which was held at the Agricultural Hall.

Domestic Electric Lighting.—Messrs. Henry Bennett and Co., of Glasgow, have recently fitted up an installation at Underwood House, Denny, the residence of R. Brown Smith, Esq., of Messrs. Smith and Wellstood, the well-known stove manufacturers. The installation consists of an Elwell-Parker dynamo, thirty 20 candle-power lamps, and twenty-five "E.P.S." accumulators. The machine is driven by a Tangye engine, which is also used for pumping water for household purposes. The fittings and globes are of a very neat design, and when the current is switched on the result is very effective.

False Telegrams.—The following notice has been issued by command of the Postmaster-General :—"Numerous advertisements having been issued in the form of fictitious telegrams, and many complaints having been received on the subject, the Postmaster-General thinks it right to call attention to the fact that the printing or circulation of fictitious telegram forms or envelopes, or of any document or form which is an imitation of a Post Office form, is an infringement of the sixth section of the Post Office (Protection) Act of 1884, and that any person acting in contravention of that section is liable to prosecution."

South Australia.—The new Loan Bill for £1,343,900, which was introduced into the Assembly on December 1, includes a sum of £17,400 for telegraph and telephone extension. The second reading of the Bill came on for consideration on December 8. The Loan Estimates were subsequently passed at £1,344,145, and a statement of excesses upon the Loan Estimates for 1884 was passed at £96,378. A handsome arcade, occupying the depth of two acres of land leading from Rundle-street to Grenfell-street, and illumined by the electric light, was opened by His Excellency the Governor on December 12.

Edison's Latest.—Edison is now said to be perfecting the phonograph. He is going to do away with shorthand writers in commercial offices. The first machine will have a five foot cylinder and be driven by steam. The sound will be transferred from the phonograph to a cylinder forty times its diameter, making the sound forty times louder than the human voice. It will have a funnel 30ft. in length. The next instrument will be for office use. Business men will dictate to the phonograph, and then hand it out to dictate to the office boy. This form of the apparatus will be self-acting, working with a spring.

Fire at Silvertown.—Soon after nine on Sunday morning an alarm of fire was raised at the India Rubber, Gutta Percha, and Telegraph Company's premises at Silvertown, and it was found that the lower part of a large four-floored building had become involved. Two rooms on the ground floor, which were used as an instrument room and lavatory, had caught fire and got well alight. The *employés* of the premises got four of the hydrants fitted to the place into operation, but although they succeeded in cutting off the spread of the flames to the upper part of the building, they could not prevent severe damage being caused to the lower portion.

Christmas Tree Lighting.—During the late festivities Mr. Penruddock successfully lighted a Christmas tree at Salisbury with fifteen 2 candle-power incandescent lamps and three chromozone cells.—At an entertainment given by the Glasgow Board of Lunacy at their Bothwell District Asylum, the Christmas tree was lighted up by Messrs. Henry Bennett and Co., of Glasgow. The installation consisted of twenty 20 candle-power Woodhouse and Rawson lamps, supplied by current from a Groves patent dynamo. The entertainment was brought to a close with a dance, the position of the lamps being altered to light up the hall.

Electric Lighting at the International Food and Cookery Exhibition.—At the recent Food and Cookery Exhibition, held at the Royal Aquarium, the stalls and exhibition were lighted by means of incandescent electric lamps. In many instances the material of the stalls was of a very inflammable nature, being composed of painted canvas, and containing lace curtains and ornamental paper in which the employment of any other than the electric light was inadmissible. In the table decoration competition it played an important part, the effect of the lamps placed among the fruit and flowers, and also on the trees in the apartments, being extremely pretty.

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Upwards of 150 lamps were employed, the work being carried out by Messrs. A. R. Sennett and Co., Hatton-garden.

THE METROPOLITAN FIRE BRIGADE.—The annual report of the chief officer of the Metropolitan Fire Brigade on the state of the brigade for the year 1885 shows that during the year there has been some development of means of communication, and now the following lines are in working order. Orders have been issued for the completion of the system, and it is probable that within the next few months the whole of the work may be executed:—28 telegraphs between fire stations, 38 telephones between stations, one direct fire alarm between stations, 42 alarm circuits round fire stations with 263 call points, three telegraphs to police stations, 18 telephones to police stations, 13 telegraphs to public and other buildings, 20 telephones to public and other buildings, and 13 direct fire alarms to public and other buildings.

ELECTRIC LIGHT AT THE THARSIS SULPHUR AND COPPER COMPANY'S MINES, SPAIN.—Messrs. Henry Bennett and Co., of Glasgow, have recently completed an installation of arc lamps at the Calânos Mines, Spain, belonging to the Tharsis Sulphur and Copper Company. The dynamo used is a Crompton 6-unit machine, and supplies current to six Crompton "D D" arc lamps of 3,000 candle-power each, driven by an 8 horse-power semi-portable Marshall engine. The object of the company in adopting the electric light is to enable them to work a night shift at their excavation work, so as to get down to the copper ore as quickly as possible. The installation is of a very complete nature, and was carried out in a highly creditable and satisfactory manner by Mr. A. W. Hine, one of Messrs. Bennett's electricians.

BOOKS RECEIVED.—"School Electricity," by J. E. H. Gordon, B.A. Camb. (London: Sampson Low, Marston, Searle, and Rivington.) A concise and useful work dealing with electricity as a practical rather than a theoretical science. Invaluable to students.—The Calendar of the University College of South Wales and Monmouthshire for the third session (1885-86). (Cardiff: Daniel Owen and Co.) A perusal of this calendar, really an extended syllabus, leaves one with a pleasant impression of the thoroughness of the University. The course is unusually comprehensive and complete, more especially as regards the Physics section. In connection with this latter an excellent laboratory and workshop has been provided, and here the students are given a thorough training in physics, or general and electrical engineering in particular.

OVERHEAD WIRES AND LOCAL BOARDS.—At a recent meeting of the Camberwell Vestry, a letter was received from the Wandsworth District Board of Works, suggesting that the several road authorities of the metropolis should ascertain and record the particulars of all cases of wires being broken in their respective districts during the recent snowstorms, with a view of the information being used in the event of the introduction into Parliament of a Bill authorising the construction of overhead telegraph and telephone wires. The committee recommended that the suggestion should be complied with, and the surveyor be instructed accordingly, in view of the proposed action of the Metropolitan Board of Works with regard to the question. The recommendation was adopted. A letter was also received from the Metropolitan Board of Works on the subiect, making a similar suggestion, with a view of measures being taken to secure greater safety to the public, which was referred to the General Purposes Committee.

THE POST OFFICE CORPS.—The annual prize distribution of the 24th Middlesex (Post Office) Rifles took place on Saturday evening in the Guildhall, when the winners received their awards from the hands of Princess Mary (Duchess of Teck), who was accompanied by the Duke of Teck and the Princess Victoria. The Lord Mayor presided.—Lord John Manners said the manner in which the Post Office and the Telegraph Volunteers had discharged their important duties was on record. He had had the privilege as Postmaster-General of communicating to the colonel in command the official commendation of the General in command of the Expedition to the Soudan of the manner in which upon a recent occasion the Volunteers of the Post Office and Telegraph Departments had discharged their duties. Those duties were performed in a manner highly efficient and entirely satisfactory to the military chiefs under whom they were rendered, and in that performance the members of the regiment encountered very real dangers and perils.

TELEGRAPHIC COMMUNICATION BETWEEN LIVERPOOL AND THE CONTINENT.—On the 25th inst. a deputation waited upon the Postmaster-General from the Liverpool Chamber of Commerce, the Liverpool Cotton Association, the Underwriters' Association, and other local commercial bodies, to urge upon him the necessity for more direct telegraphic communication between Liverpool and the Continent. The deputation was accompanied by several members of Parliament. Mr. Smith, the Chairman of the Chamber of Commerce, stated that what they really wanted was that they should be able to telegraph from Liverpool to the Continent after the markets were opened, and to receive a reply before the markets closed the same day. The Postmaster-General, in reply, reminded the deputation that the matter rested partly with the Cable Companies, in concert with whom, however, the Government was desirous to act, so as to facilitate the communication. He hoped that before long direct telegraphic communication might be established between Liverpool and Havre. He would carefully consider the representations made, and hoped that the Government might be able to effect the desired improvement.

ELECTRIC SIGNALLING FROM BALLOONS.—By direction of the War Office, experiments in army signalling of a novel and interesting character were begun on Saturday evening last at the Army Signalling School, Aldershot, under the superintendence of Major Thrupp, when Mr. Bruce, son of Major-Gen. Bruce, attended to exhibit his balloon signalling apparatus. The balloon holds between 4,000 and 5,000 feet of gas. The interior is illuminated by six incandescent lamps of about 15 candles each, which can be increased up to 100 if necessary. A 25-cell battery was used, and the signalling was carried on by means of a key similar to that used on telegraph instruments, which charged the lamps for short and long periods. The balloon, which was made captive to a stake driven in the ground, ascended about 500ft., and a party of signallers having been sent out some miles away from the camp, several messages were sent and read by the signallers and replied to by the limelight, under very unfavourable atmospherical conditions, it being very foggy and snow falling the whole time. The light was also tried outside the balloon. It is understood that further experiments with this system will be carried out.

PRESCRIBING BY TELEGRAPH.—It is said that some of the operators in the service of the Western Union Telegraph Company at New York are graduates in medicine. It recently happened that one of them had his attention attracted by a message which stated that a certain physician at a place three miles distant was wanted immediately to attend a young person who had just swallowed an ounce of laudanum. The student-operator asked at once for all the particulars, and on receiving them a consultation was held at the New York office.

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It was decided that it would be hazardous to postpone treatment until the doctor could be found and driven three miles to attend a patient in so dangerous a condition. The council therefore telegraphed the operator at the office nearest to the patient's residence to see that powerful emetics were administered, suggesting home made ones, such as lukewarm water and mustard and water, after which the patient was to be vigorously rubbed and whipped with switches to prevent sleep. This unexpected order was faithfully carried out, and with such happy results that the poison failed to act. Something like this was done, if we mistake not, at Manila about a year ago.

Military Mines.—At a meeting of the Royal United Service Institution, held at Whitehall-yard, on Wednesday last, Major Sale, R.E., read a paper on "Land Mines." The lecturer, in opening his address, said that he did not propose to touch upon that branch of military mining which involved the use of shafts and galleries, and such like subterranean warfare, but rather to deal with that class of small surface defence mines which might be more properly termed land torpedoes. In the recent operations at Suakim mechanical mines were used, and as the Arabs showed the most extraordinary keenness in detecting any kind of tripping wire or safety line, the torpedoes were set to explode when trodden on, and without safety lines for recovery. Briefly, it might be said that mechanical mines were unsatisfactory, imperfect, and decidedly dangerous, and should not be used except under very special circumstances. Upon the whole it appeared to the lecturer that the advantages to be gained by the use of electricity so decidedly preponderate over the drawbacks, that this mode of firing land mines should in almost every case be preferred to mechanical methods. Commander Kingscote said that in the Zulu war they had found land torpedoes most useful. For ordinary purposes the mines must be electrical, but in warfare against savage nations mechanical mines were very useful in fighting the natives.

A Telephone Exchange at Keighley.—After a considerable time spent in negotiations the National Telephone Company have at last opened an exchange at Keighley. During the course of the inaugural ceremonies Major Harrison said he was very glad that they had been able to open an exchange at Keighley. They had been in operation in Yorkshire for the past four or five years, and they had looked forward to establishing a large exchange at Keighley. They had already exchanges at Bradford, Leeds, Halifax, Dewsbury, Batley, and Wakefield. Keighley had been rather a sore point with them, because they had never been able to get a sufficient number of guarantees to justify them in establishing at once an exchange there. However, they had now been able to accomplish their object, and he trusted that Keighley would in a short time prove to be one of their largest as well as one of their best paying exchanges. These telephone exchanges had already proved to be of great service in other towns in Yorkshire, and now that the Keighley Exchange had been established he hoped soon to see it extended to Skipton. In Bradford there were already ninety private houses in connection with their exchange. To make a town exchange a success they required numbers, and in Keighley there had not yet been a sufficient number of subscribers for this purpose. He was certain that when they became familiar with the uses of the telephone that number would be largely increased.

Electric Light versus Gas.—The following letter appeared in a recent issue of the *Accrington Times*:—"In consequence of the proposed purchase of the gasworks I have been surprised that so little has been said about electric light, and as an unprejudiced ratepayer I desire to say a few words on this subject ere it be too late. It behoves the ratepayers to be careful to protect their interests, and not allow the corporation to act without a full and fair inquiry and a thorough test of the electric light. It is generally supposed that the electric light is only adaptable to large areas, and that it cannot be utilised for mills, workshops, and houses; but this is an error, as the light is now used in corn mills, woollen mills, weaving sheds, workshops, and private dwellings, and the saving in cost is as much as £200 on a place hitherto costing £300 per annum for gas at 3s. per 1,000ft. I have before me a list of fifty mills and private residences which are now using electric lamps alone at a great advantage in cost, health, and comfort, and considering the difficulties through prejudice and the vested interests of shareholders in its gigantic rival, and the short time that has elapsed since the electric light made its appearance, the progress established is satisfactory; and we should be on our guard against bartering away our freedom of action in this important matter. There is no urgency for taking over the gas works, and it were preferable to postpone the subject indefinitely rather than act injudiciously on one-sided data. Should the report of the committee recently appointed by the Council prove that its merits have been fully tested I earnestly appeal to those who have the welfare of the town at heart to claim a fair trial for the electric light before giving their countenance to what may hereafter be found an egregious blunder."

A New Thief Catcher.—Some dishonest men, whose arrest was brought about in a singular manner, have been dealt with at the Thames Police-court. The accused were James Andrews, who was charged with stealing meat, and Henry Saunders, George Turner, and Thomas Galley, who were charged with unlawfully receiving it. Andrews was a shopman in the employ of a butcher named Chapman, who for some time had missed large quantities of meat. In consequence of this he communicated with the police. Returning from market one morning earlier than usual, he secreted himself in a box, from which he could command a view of the shop. Before the shutters were taken down he saw about half a dozen men come in and receive meat from Andrews. To bring these offenders to justice he hit on a novel plan. He arranged with several detectives to signal to them from an electric light which he fixed on the top of the house, and connected with his place of concealment. Again he watched, saw Saunders come into the shop, and Andrews give him a shoulder of mutton, a piece of beef, and some sausages. On Saunders leaving with the meat, Chapman "switched" on the electric light. Two or three minutes later Turner came in. He purchased a small article, and some money passed between him and Andrews. The latter then pushed him over a large piece of mutton, which he quickly wrapped up, and went out. Saunders again switched on the lamp, and signalled the detectives. Galley then came in, and the same performance happened. Then someone came in and gave Andrews the "tip," and he left the shop, but was afterwards brought back by one of the detectives who had arrested his accomplices. The magistrate sentenced Andrews to three months', Saunders to three months', and the other two prisoners to fourteen days' imprisonment, all with hard labour.

Overhead Wires.—In the House of Commons on Monday night Sir H. Tyler asked whether attention had been drawn to the failures of telegraph and telephone wires used overhead in the metropolis during the recent snowstorm, and to the accidents which had been occasioned thereby; whether a

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return of these failures and these accidents would be prepared and presented to the House; and whether any steps would be taken to prevent this constantly increasing danger to all persons using the streets of the metropolis.—Lord J. Manners replied that his attention had been drawn to the failure of telegraph wires during the recent snowstorm, and he was glad to be able to state in reply to the question of the hon. member that no case of accident to any human being has been caused by the wires belonging to the Post Office. A large proportion of the overhead wires in the metropolis did not belong to the Post Office, and the Department had no means, therefore, of furnishing the return asked for. The policy of the Post Office for many years past had been to substitute underground for overhead wires in London, and also in other large cities, wherever the extra expense involved could be justified, and since his appointment he had given renewed instructions on this point. He might add that the mileage of postal telegraph wires in the metropolis on the 31st of December was 9,832 miles, of which 9,005 miles, or about 11-12ths, were underground wires. In the eastern central and western central postal districts, which comprise the half of the metropolis, there were only 44 miles of overhead wires the property of the Department. As the House was aware, a Select Committee was appointed last session to consider the law relating to the control over telephone, telegraph, and other wires, and made a report, but it has not been considered desirable to take action in the direction of the course recommended in that report.

ACTION AGAINST A TELEPHONE COMPANY.—On the 25th instant, in the Lord Mayor's Court, before the Recorder and a common jury, the case of Harris *v.* the United Telephone Company was heard, in which the plaintiff, a dentist in the Mile End-road, sought to recover from the defendants £8. 15s. expenses he had been put to in repairing a wall which it was alleged was damaged by one of the defendant company's poles. Mr. Harte was counsel for the plaintiff; Mr. Scott for the defence.—Mr. Harte said his client was applied to some five years ago by the defendants to allow a pole to be placed in his garden, to which after a time he consented. A pole 60ft. in height was subsequently placed in a corner of it. It carried thirty-eight or thirty-nine telephone wires, and was supported by means of stays, and came within a few inches of the wall in question. For some years no rent was charged for it, but subsequently an arrangement was come to that the plaintiff should have telephonic communication between his surgery and his private house, the company agreeing to pay him £2. 10s. a year for the right and use of the garden for their pole, and the plaintiff to pay £5. 10s. for the use of the connection; the company undertaking to be responsible for the erection, maintenance, and removal of the pole. In May last the plaintiff had notice from the local authorities that the wall had become unsafe, and had to pull it down and rebuild it, at the cost now sued for. The cause, it was alleged, was that the stays having weakened the wall, made the pole lean towards it.—The learned Judge: But the pole never touched it.—Mr. Harte: No, my lord.—The learned Judge: Then the wall got frightened?—Mr. Harte: No, not frightened, except it might be said it became frightened yielding to undue pressure.—The defence was a denial that the injury was caused by the pole in any way, but that it was the result of the unsound condition of the wall.—The jury found a verdict for the plaintiff for the amount claimed.

THE ITALIAN TELEGRAPH ADMINISTRATION.—From the Italian "Yellow Book," recently issued, relating to the progress of telegraphy in the Kingdom of Italy during the year 1884, we learn the following interesting particulars:—In the course of that year 179 fresh offices were opened for public business, 80 of which were Government offices, the remaining 99 being offices made available for that purpose at various railway stations. Partly in connection with the opening of these new offices, and partly in consequence of extensions of the system, additional lines have been erected over 423¾ miles of country, with a length of wire amounting to 3,693½ miles. Adding these to the lines existing in 1883, the report shows a present total of 18,132 miles of line, representing 64,052 miles of wire. The number of offices worked by Government clerks is now 1,927, and of offices at railway stations open for the reception of public messages 988, making a total of 2,915 for the whole kingdom As regards the traffic, the increase has apparently kept pace with the improved facilities. The total number of telegrams from all sources dealt with by the Italian Administration during the year was 7,738,227, which is 561,704 in excess of the total for 1883. This total includes, of course, all telegrams, whether foreign, inland, or such as merely pass over the Italian lines from one foreign country to another. Of this total 6,260,853 were inland telegrams, being an increase of 441,843 on the previous year; whilst foreign telegrams increased by 74,680, bringing up the total of messages despatched to and received from foreign countries to 1,271,631, the remaining 205,743 messages representing the transmitted foreign traffic. The revenue for the year amounted to £495,755, against an expenditure of £399,956, leaving a profit of £95,799. This account, however, does not appear to include any estimate of cost for the transmission of Government messages. The report is signed by Sig. E. D'Amico, the Director-General of Telegraphs for Italy.

ELECTRIC LIGHTING IN BRIGHTON.—In addition to the system on the Pavilion Estate, worked under the direction of the town council, with their own plant, the Brighton Electric Light Company are now supplying power for nearly 1,000 incandescent lamps. The whole circuit extends over about eight miles, running from the central station to Preston-street on the west, along the sea front and up to Dorset-gardens on the east, and to the railway terminus on the north. This northern district circuit now simply supplies the railway station, which is lighted solely by electricity, but in a short time it will be extended to the locality of the Level and Lewes-road, and leads will also be carried on to Hove. The power is supplied on the high tension system. Brighton is the only town in England where the arc and incandescent lamps are run on the same circuit. The central station in Gloucester-road now consists of a large square newly-erected brick building. Workshops have yet to be erected in the rear, on the site of the old station. The three engines formerly used there are now in course of removal, and when the shops have been completed, all the company's repairs will be executed here, including the repairs to lamps. The engine now in use is a large compound, by Fowler, of 200 horse-power, the fly-wheels and shaft of which weigh five tons. This drives three 40 lighter dynamos, and together these are capable of sustaining a hundred and twenty 2,000 candle-power arc lamps. The machinery which generates the power now runs from dusk to 1 a.m.; but the directors contemplate adding another and a more powerful engine, so as to provide for further demands on their resources, and also in order that, if found to be necessary, the supply may be continuous through day and night. At the railway terminus alone sixteen 2,000 candle-power arc lamps are in use, and the light is also installed at the Orleans Club, the Chapel Royal, the Theatre, the Oxford Music Hall, the Aquarium, and at several hotels, restaurants, and places of business. A further enlargement of the system at the Grand Hotel is contemplated.

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THE SUN—A POINT OF VIEW.

BY ALEXANDER J. S. ADAMS.

Of marvels, one of the greatest is the sun; his wonderful heat, his resplendent light, and the undiminished continuity of his glory.

How few of us more than wonder at the strange and beautiful orb; and yet there is much of intensest interest in his daily doings.

One important feature about him is the tiny looking spots that, now singly and now in groups, trip across his face, and which, at all events in the case of the larger spots, affect our globe to probably a greater extent than at first sight appears, and sometimes by exhibitions of electric force play pranks with the otherwise orderly flow of electricity upon our telegraphic systems.

Little may be known regarding the physical properties of the sun, but we should grasp to some extent the apparent meaning of the sure connection that exists between the large spots and the earth.

Sometimes it is a single spot of larger size and darker hue, at others groups of spots, small individually and ill-developed, that rush across the sun's face, although it seems that only the larger spots are found to disturb our telegraphic peace; and even they fail to produce effects upon our lines until in passing across the sun's disc they reach a position near its centre.

Thus, in April, 1882, although a large spot was clearly visible as it came round the western edge of the sun, it was not until five days later, and when the spot had reached the centre of the disc, that a violent electric storm, lasting three days, took possession of our globe. The same spot remained visible for several days afterwards, but without effecting further disturbance.

In November, 1882, a spot of considerable magnitude passed across the sun's face, and it was only during its presence at the centre of his disc that a shock of electrical disturbance visited us.

A further experience of the kind occurred so recently as January in the present year, when a large spot became visible at the western edge of the sun's disc on the 2nd or 3rd, although it was not until the 9th that for thirteen hours an electrical disturbance manifested itself.

As I write there is a group of four goodly spots at the very centre of the sun's face, which, if they were rolled into one, would in the aggregate more than equal the last single spot referred to; yet, in the case of this fine group, as in the case of similar groups, there is the remarkable difference that no electrical effect is apparent.

Surely this variance in the effectiveness of groups, as against large single spots, should teach us something; and the lesson taught by these experiences would seem to be that the causation for these shocks to our globe cannot reside upon the *surface* of the sun, otherwise the earth would feel the influence at any time during the period that the spot is visible. The seat of the outcoming force must lie at some far-reaching depth, from whence the force rays only reach the earth when the sun spot vortex directly faces us.

From this point of view, then, we will start. Known laws indicate that in the interior of the blazing sphere will be a solid body; that beneath the burning gassy exterior as viewed by us there will be a nucleus, perhaps a cool hard globe, revolving about its axis at a rapid pace and possessing magnetic power vastly beyond our computation. Around this solid nucleus, yet thousands of miles above its surface, would float an atmosphere—a metallic gassy envelope thousands of miles in thickness, not cloudy, but heated to the intensest degree by the mighty magnetic rays showered upon it by the nucleus.

The fact that a wire moving near a magnet will gather up its rays and in due time transform them into heat and light will serve as a fair illustration.

The whirling of the inner globe goes ever on, and its forces are driven forth, to be gathered up by the solar envelope and turned to heat. The heat thus constantly generated in the inner parts of the sun's envelope will be as constantly transmitted to the outer parts, and thence, by radiation, quickly dissipated, maintaining thereby those outer parts at a comparatively moderate temperature.

The condition of things would therefore be, that whilst the inner parts of the sun's envelope are composed of mixed, most intensely heated metal gases, radiation from the outside will cool and decompose the mixed gases into clouds and banks of heated metallic vapour, each, after its kind, producing the grainy, puzzling appearance so well known to astronomers.

From the action of boiling liquids we may gather the terrific struggle for supremacy that goes on between the super-heated gases of the inner portion and the cooler and more condensed parts outside—a struggle in which the underlying depth of heat may sometimes gain the mastery, and tearing upwards will distort and rend the outer covering in its career.

That a mastery of the inner over the outer portions of the envelope once gained should remain for a considerable period is not unlikely; and that such is the fact may be gathered from the frequent long continuance of individual spots.

In the case of the more considerable eruptions it is possible that the forcing aside portions of the sun's envelope will offer, for some at least of the nucleus force rays, a means of escape into space; thus it will be not enough that a sun-spot vortex be turned towards the earth to affect it, there must also be a sufficient denudation at the point of rupture to permit the force rays to pass through, and the strength of the disturbance will in large measure be proportional to the freedom of the passage provided.

It may be advanced that the necessary energy at the nucleus for so splendid a result is improbable; that such an enormous exhibition of force could not last the ages; but it should be borne in mind that although electricity and magnetism are unravelled mysteries, it would really seem not only that enormous energies may be drawn from comparatively small magnets, but that their hidden springs were also inexhaustible. A moderate computation would demonstrate that the few rays which actually strike the earth will possess an energy at the sun's surface amply adequate to the task here sought to claim for it.

THE STEAM ENGINE INDICATOR.—XIV.*

BY AMICE.

Our means of comparing an indicator diagram with the diagram which would be obtained from a steam engine were it not for practical sources of loss more or less unavoidable, but which steam engine builders do their best to make as small as possible, would be incomplete without the curve which is obtained by plotting the pressures and volumes of a given weight of steam at different temperatures. We have thus far only dealt directly with pressures and corresponding volumes of steam, temperature having been taken into consideration indirectly only, though we have referred to the condensation of steam during the commencement of the stroke of the piston consequent upon the entrance of the steam to a cylinder which has been cooled down to the temperature of the exhaust, or approximately thereto, and to the consequent fall in pressure. We have also referred to the rise in pressure of the steam during the expansion part of the stroke, consequent upon the re-evaporation during expansion of the steam so condensed, that re-evaporation taking place as the pressure falls to that under which the condensed steam will boil, and continuing to do so until exhaust takes place. It would be more correct to speak of this as a maintenance of pressure rather than a rise of pressure, as the re-evaporation does not cause a rise but retards the fall of pressure. It must be remembered that the pressure and temperature of saturated steam—that is, steam in the presence of the water from which it is evaporated—rise together, though not exactly in the same ratio. Every given weight of saturated steam has a definite volume, pressure, and temperature. That is to say, any given weight of water will give a specific volume of steam at a specific temperature or pressure. This is

* For Art. 13, see *The Electrician*, 25th December, 1885.

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known as specific or relative volume. By plotting specific volumes and pressures we obtain a curve which differs somewhat from the so-called isothermal curve or hyperbolic curve, and from the adiabatic curve, and is in many cases rather nearer the actual indicator diagram than either of these. It is, however, almost as often so, partly as a result of a combination of contributing causes, including clearance, initial condensation, and subsequent re-evaporation, which in other cases may operate to make it incorrect, but inherently it is more correct as a theoretical curve than either of the others. It deals with steam as steam, and represents graphically the results of the experiments of Regnault, Fairbairn, and others, made under conditions which are very much those of the steam engine, except as to the sources of loss above mentioned. The following table gives a few corresponding temperatures, pressures, and volumes merely for convenience in dealing with the curve to which we refer, such a curve being very useful as a comparison with diagrams obtained from the steam engine cylinder.

Table C.—Relative Pressure, Temperature, and Volumes of Saturated Steam.

Pressure in lbs. per sq. inch.	Temperature. Fah.	Specific volume. Water at 40°, being 1.
5·00	162·37	4627
10·00	193·29	2429
14·68 (atmospheric)	212·00	1702
15·00	213·07	1669
20·00	228·00	1280
25 00	240·20	1042
30·00	250·40	881
35·00	259·3	764
40·00	267·3	676
45·00	274·4	608
50·00	281·0	552
55·00	287·1	506
60·00	292·7	467
65·00	298·0	434
70·00	302·9	406
75·00	307·5	381
80·00	312·0	359
90·00	320·2	323
100·00	327·8	293

The figures of the first and last of these columns set off on the vertical and horizontal scales, as in the accompanying engraving

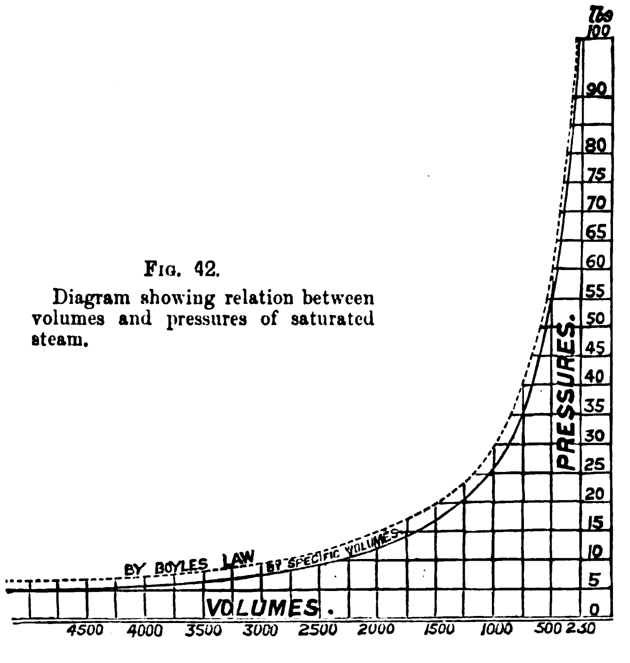

Fig. 42.
Diagram showing relation between volumes and pressures of saturated steam.

(Fig. 42), give us the curve of specific volumes, from which it will be seen that the volumes do not quite bear an inverse ratio to the pressure; and, in fact, the departure is considerable, the specific volume curve leaving the dotted curve, traced according to Boyle's law, by a perceptible distance even at the higher limits. This really is the curve we should obtain from the steam engine if the cylinder were at the temperature of the incoming steam, and fell in temperature only in accord with the fall in pressure, due to increase in volume during expansion.

CORRESPONDENCE.

ON THE RISE AND PROGRESS OF NOMENCLATURE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The importance of nomenclature was recognised in the earliest times. One of the first duties that devolved upon Adam on his installation as gardener and keeper of the zoological collection was the naming of the beasts.

The history of the race is repeated in that of the individual. This grand modern generalisation explains in the most scientific manner the fondness for calling names displayed by little children.

Passing over the patriarchal period, the fall of the Tower of Babel and its important effects on nomenclature, the Egyptian sojourn, the wanderings in the desert, the times of the Kings, of the Babylonian captivity, of the minor prophets, of early Christianity, of those dreadful middle ages of monkish learning and ignorance, when evolution worked backwards, and of the Elizabethan revival, and coming at once to the middle of the 19th century, we find that Mrs. Gamp was much impressed by the importance of nomenclature. "Give it a name, I beg. Sairey, give it a name!" cried that esteemed lady. She even went so far as to give a name to an entirely fictitious personage—Mrs. Harris, to wit—who has many scientific representatives.

Having thus fortified ourselves by quoting both ancient and modern instances, let us consider the names of the electrical units.

A really practical name should be short, preferably monosyllabic, pronounced in nearly the same way by all civilised peoples, and not mistakable for any other scientific unit. If, in addition, it be the name, or a part of the name, of an eminent scientist, so much the better. That is quite a sentimental matter; but if it does no harm, it is needless to object to it. But we should never put the sentiment in the first place, and give an unpractical name to a unit on account of the sentiment.

Ohm and volt are admirable; farad is nearly as good (but surely it was unpractical to make it a million times too big—the present microfarad should be the farad); erg and dyne please me; watt is not quite so good, but is tolerable. But what about those remarkable results of the Paris Congress, the ampère and the coulomb? Speaking entirely for myself, they are very unpractical. Coulomb may be turned into coul, and is then endurable; this unit is, however, little used. But ampère shortened to am or amp is abominable. Better make it pere; then it will do. Then an additional bit of sentiment comes in to support us. Was not Ampère the father of electrodynamics?

It seems rather unpractical for the B.A. Committee to have selected 10^8 c.g.s. as the practical unit of E.M.F., instead of 10^9. This will hardly be appreciated except by those who make theoretical calculations; the awkward thing is that the père is one-tenth of the c.g.s. unit of current. I suppose it was because the present volt was an approximation to the E.M.F. of a Daniell; that is, however, a very strong reason for making the practical unit much smaller; because the E.M.F. of a cell has now to be given in volts and tenths, or hundredths also. How awkward it would be if the ohm had been made 10^{10} c.g.s., so as to approximate to the resistance of a mile of iron telegraph wire. The ohm and volt should be the same multiple of the c.g.s. units, both 10^9 for example. Then use the millivolt or centivolt when speaking of the E.M.F. of cells. The present 1·12 volt would be 112 millivolts. Speaking from memory of reading something somewhere, Sir W. Thomson did object to the 10^8 volt at the Paris Congress.

Mac, tom, bob, and dick are all good names for units,

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Tom and mac (plural, max), have sentimental reasons for adoption, bob and dick may also at some future time. I have used tom myself (no offence, I hope) for six years past to denote 10^9 c.g.s. units of self or mutual electromagnetic induction coefficient. (Some reform is wanted here. Coefficient of self-induction, or of electromagnetic capacity, is too lengthy). The advantage is that L toms divided by R ohms gives L/R seconds of time. But it is too big a unit for little coils; then use the millitom; or even the microtom for very small coils. This applies to fine wire coils. The c.g.s. unit itself would be most suitable for coils of a few turns of thick wire. If it is called the tom, then the kilotom or megatom will come in useful for fine wire coils.

A name should certainly be given to a unit of this quantity, whether it be tom, or mac, or any other practical name. Also, names to a unit of magnetic force (intensity of), and of magnetic induction.

There is also the question of the names, not of the units, but of the physical magnitudes of which they are the units, but it is too large a question to discuss here except in the most superficial manner. It is engrained in the British nature to abbreviate, to make one word do for two or three, or a short for a long word. And quite right too. We have much to be thankful for; in the application of this general remark, consider what frightful names might have been given to the electrical units by the Germans. But, on account of this national, and also rational tendency to cut and clip, it is in the highest degree desirable that as many as possible of the most important physical magnitudes should be known, not by a long string of words, but by a single word, or the smallest number possible.

Thus, I find myself frequently saying force, when I mean magnetic force, and even then, I mean the intensity of magnetic force. The context will generally make the meaning plain. But it is necessary to be very careful when there are more forces than one in question. (This use of force as an abbreviation is, of course, quite distinct from the frequent positive misuse of the word force, to indicate it may be momentum, or energy, or activity, or, very often, nothing in particular, the misuser not being able to say exactly what he means; nor does it much matter.) It would be decidedly better if such a quantity as "intensity of magnetic force" had a one-word name, for people will abbreviate, and sometimes confusion may step in. This remark applies to most of the electro-magnetic magnitudes.

There is an important magnitude, the magnetic induction. I call it often simply "the induction"; but in doing so, carefully avoid calling any other quantity "the induction" (sometimes the electric displacement is called the electric induction.) But there is an unfortunate thing here, which somewhat militates against "the induction," or even "the magnetic induction" being a thoroughly good name for the magnitude in question. This is, that besides being a name of a physical magnitude, the word induction has a wide-spread use, in a rather vague manner, in connection with transient states in general, whether of the electric or of the magnetic field, exemplified, to take an extreme example, when a man explains something complex by saying it is caused by "induction," and so settling the matter. If this vague qualitative use of induction were got rid of, then as a name for a physical magnitude it would be unobjectionable. As it is, it is a question whether the physical magnitude should not have a name for itself alone.

"Resistivity" for specific resistance, and "conductance" for what is sometimes called the conductibility of a wire, *i.e.*, not its conductivity (specific conductance), but the reciprocal of its resistance, are, I think, as I have remarked before, quite practical names.

The further consideration of nomenclature must be postponed.—Yours, &c., OLIVER HEAVISIDE.

RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* of January 15th somebody wishes to be acquainted with the difference in resistance and conduction between a solid bar and a hollow cylinder of the same length and diameter.

On the one hand, the statement that conductivity is in the direct and resistance in the inverse ration of the area is proved fully; but, on the other hand, the assumption that electricity *flows over a surface* has never been proved and is altogether wrong. In the state of electrical equilibrium, where no motion takes place, electricity rests on the surface, indeed; but being in motion it must be supposed to be flowing through every part of the body.—Yours, &c., E. WENK.

116, Mildmay-road, N., 23rd January, 1886.

THE DYNAMO AS A GENERATOR AND A MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have to thank Mr. Walker for his kind remarks on my paper on "The Dynamo as a Generator and a Motor." With reference to Mr. Walker's criticism of some points in the paper, it is not necessary that I should do more than point out that he has apparently misunderstood those portions of my brief paper in which he considers that "from a controversial point of view" I have been unfortunate. He will see, if he looks over the paper again, that he is not correct in stating that I intimate that experiments point to a certain result, and then prove the contrary. It will, I am sure, be sufficient if I point out to him that he has confused a compound and a shunt dynamo. I do not mention the former in my paper.

With regard to the question of the efficiency of electric motors, I wish to point out that the tabulated figures given in the paper are not to be taken as indicating a low efficiency. An unascertained loss in transmission was *not included* in the horse-power readings, and should therefore be added to them. By a clerical error this unascertained loss is stated to be *included* in the horse-power column.

As a matter of fact, other experiments show that the commercial efficiency of the Victoria motors (or the ratio of the power delivered in a useful form at the pulley to that absorbed at the terminals) is over 80 per cent.

I am glad to be able to say that, since writing the paper, I have seen reason to considerably modify the view therein expressed as to the amount of the effect produced by the difference of the character of the induction of eddy currents in generators and motors. The difference will probably not be found of such importance as to furnish a very strong argument against the use of iron in the armatures of the latter.

I have read Mr. Brand's letter with interest, and am pleased to see that his experience accords so completely with the principles and views indicated in the paper.—Yours, &c.,

W. M. MORDEY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Some months ago in the course of a short conversation with Mr. Mordey I stated it as my belief that a practical computation of the loss by eddy currents and friction in a dynamo when run at a given speed could be made by running the dynamo as a motor with no load, the E.M.F. at the terminals being varied until the required speed was obtained.

Thus, $CE =$ the total energy delivered to the motor, where E is the E.M.F. at terminals and C the current flowing through the motor.

$CE - \{c^2r + c_2^2r_2\} =$ energy absorbed by friction and eddy currents, where $c^2r =$ energy absorbed by field-magnets, and $c_2^2r_2 =$ energy absorbed by armature, due to the inherent resistance of the wires, my argument being that whether the dynamo was used as a motor or as a generator, the loss from eddy currents and friction (neglecting the increase of the latter caused by the band when used as a generator) must be practically the same, especially as the brushes did not require moving.

Since a considerable time before the above-mentioned conversation I have subjected to this test the dynamos manufactured by the company with which I am connected, always remembering, however, that my theory was as yet unproved by experiment.

Mr. Mordey withheld a decided opinion, but thought that the conditions existing when the dynamo was run as a

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generator would be very different to those which exist when used as a generator. It was, therefore, with particular interest that I read the reprint of Mr. Mordey's paper in your issue of the 15th inst.

I should now like, with your permission, to offer a few remarks on the subject in question—with some reference to Mr. Mordey's paper—the purport of which is sufficiently indicated by the heading of this letter.

Mr. Mordey's statements with reference to magnetic distortion seem to me to be rather confused, but I pass them over as unimportant. With reference to the speed of a motor when supplied with constant E.M.F. at terminals and varying load, Mr. Walker has shown with sufficient clearness that there can be no increase of current in the armature without decrease of back E.M.F., which, we may assume, means decrease of speed, as the total effect of self-induction, in the case of motors, tends to produce increase of field and consequent decrease of speed, as we shall see later on.

I would point out that the theoretical conditions under which a dynamo used as a motor *would* have a constant speed with a constant E.M.F. and varying load, are precisely those under which it would yield a constant E.M.F. with varying current when used as a generator—*i.e.*, when the armature resistance and self-induction are both *nil.*

At the end of his paper Mr. Mordey assigns a reason why dynamos should be less efficient as motors than as generators; but I think if he had investigated his theory a little more carefully he would have seen that if there is any difference in the eddy currents in the two cases it must be very trifling. What increase there is when the dynamo is used as a motor must be due to the lead of the brushes, as I will now endeavour to show.

With a dynamo having an infinite number of sections on the commutator (or the brushes sliding on the conductor), except at the point of commutation the current in the armature would be perfectly constant and stationary relatively to the iron core, and consequently its action would be *nil.* Or, to be more exact, we may say that as the induction due to the increase and decrease of the eddy currents in the core (as the iron approaches and recedes from the pole pieces) upon the steady current in the armature is inverted during half the process, the total result is *nil.* The effects of the rise and fall of the current due to a commutator with a practical number of sections are also equal and opposite. It appears, then, that the only part of the armature where the current in its coils can affect the E.M F. which produces the eddy currents (*without affecting similarly* the E.M.F. in the coils themselves, which it does by weakening or strengthening the general field) is the part surrounding the line of commutation, where there are what have been called "consequent poles," due to the change of direction of the current in the coils. These consequent poles will be respectively nearer the field-magnet pole on one side of them than on the other by the amount of double the lead of the brushes. In the case of the generator they will be nearer the pole of the same name as themselves, and will consequently be *lessened* in intensity by induction. In the case of a motor they will be nearer the pole of opposite name to themselves, and will consequently be *increased* in intensity by induction. If there were no lead, the consequent poles would be placed centrally between the field-magnets in each case; and the inductive effect the same, whether as a motor or generator.

But these consequent poles have a far more important effect than producing eddy currents in the iron, in a practical dynamo. They are the chief cause of the current in the short-circuited coil; and there, as I take it, lies one of the main causes of the inefficiency and excessive sparking of early dynamos when used as motors. The loss from this cause will obviously be at a minimum with the greatest possible number of sections in the commutator, and the smallest possible magnetising effect of the armature coils; and the *difference* between the loss when used as motors and the loss when used as generators will also be least when the magnetising effect of the armature coils and consequent lead is at a minimum.

The following tables, produced from Mr. Mordey's figures, show conclusively that the effect of the armature current on the eddy currents is practically *nil.* Column 4 represents the energy absorbed by the motor, and if Column 6 is subtracted from it the remainder represents friction (air churning) and eddy current.

1. Speed.	2. Energy delivered to motor h.-p. = $\left(\frac{CE}{746}\right)$	3. Useful h.-p.	4. Difference h.-p.	5. Efficiency.	6. Loss due to inherent res. of armature coils h.-p. = $\left(\frac{c^2 r}{746}\right)$.
975	6·8	1·8	5	26·5%	·053
965	12·4	6·6	5·8	53· %	·179
948	18·3	12·9	5·4	70·5%	·38
945	24·7	16·3	8·4	66· %	·69
680	3·9	1·	2·9	25·5%	·034
677	8·25	4·8	3·45	58· %	·153
675	13·7	9·14	4·56	66·8%	·42
660	16·5	11·7	3·8	71· %	·61

From these tables it would appear that the loss from eddy currents is actually less with a heavy current in the armature coils instead of being greater, as Mr. Mordey's theory would necessitate if it were true. But this is very likely due to considerable inaccuracies in the experiments and readings, which evidently exist, and which it is not easy to avoid.

If Mr. Mordey would favour us with the results of further experiments, he would, no doubt, confer a great boon on your readers, and I sincerely hope, with Mr. Walker, that he will be kind enough to do so.

In the case of the generator, the magnets are having work done on them by the armature, and the inductive result is to *strengthen* the magnetisation of both, but the effect of the armature current is to *decrease* that magnetisation.

In the case of the motor, the armature is having work done on it by the magnets, and the inductive result is to *weaken* the magnetisation of both, but the effect of the armature current is to *increase* that magnetisation. The relative strength of field of the dynamo when run as a generator and as a motor will therefore depend upon which of these two effects is the more powerful.

The first effect remains practically constant in each case. The second effect varies with the strength of current in the armature, and tends to produce a decrease of E.M.F. when the dynamo is run at a given speed as a generator, and a decrease of speed with a given opposing E.M.F. when run as a motor.

Early dynamos, as everyone knows, had far greater length of conductor on their armatures than those now constructed, and the magnetising effect of the armature (tending to increase the strength of field when run as motors) was very great. We know that when used as generators the total E.M.F. fell off considerably, on account of the reduction of the strength of field, or, as it is called, self-induction. So we may assume that when these machines were run as motors, the field strength was increased by the inverse action. Now, the effect of the increased strength of field is to produce the requisite opposing E.M.F. (which determines the limit of speed) at a slower speed, from which we should conclude that a motor will have a back E.M.F. of a given value, at a speed lower than the speed at which it would produce that E.M.F. as a generator.

From these considerations it appears that the following conclusions can be drawn:—

1. That it may be possible to construct dynamos which shall have practically the same efficiency *whether used as a generator or as a motor.*

2. A dynamo will have a given E.M.F. (opposing in the case of a motor) at a lower speed as a motor than as a generator, and the *difference* will be greater or less as the variation of strength of field from self-induction is greater or less.

3. *At the same speed* a dynamo will have a larger output when used as a motor than when used as a generator, and will require a greater E.M.F. to drive it than it would produce as a generator.

4. The loss of energy from eddy currents in a dynamo, whether used as a motor or as a generator, will be the same when the E.M.F. generated (opposing in the case of the motor) is the same.—Yours, &c.,, W. B. Sayers.

Birmingham, Jan. 26, 1886.

[*For continuation of* Correspondence *see page* 231.]

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

VOLUME XV.

Volume XV. of "The Electrician," price 10s. 6d., is now ready. Also cases for binding, price 2s.

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THE WORKING OF THE PATENT ACTS.

Writing on the subject of the new Patent Law just before it came into operation on the 1st January, 1884, we predicted that its working would demand and receive very close watching, which, in the course of a few years, would result in an inquiry and a remodelling of the Act. Our prophecy, in at least one particular, has come true rather sooner than we expected. After an existence of barely two years, the organisation and duties of the Patent Office, under the Patents, Designs, and Trade Marks Act of 1883, are to be overhauled by a Committee of the Board of Trade, and the investigation is now proceeding. We are not informed as to the exact defects which have called forth this step; but we may be sure that it is the outcome of complaints against either the provisions of the Act or the way it has been administered. In our article of December, 1883, we pointed out that in both respects the measure was seriously defective, its stipulations being delusive as affecting the inventive novice, and its working being liable to abuses that would press heavily on the experienced patentee. We have reason to believe that the warnings, which passed unheeded at the time, have been only too speedily realised, and that the present inquiry is the result of complaints which have grown too pressing to be disregarded. It is greatly to be hoped that the political incident of Tuesday night may not cause this Commission to be prematurely broken up.

Not the least of the evils introduced by the new Act was the multiplication of abortive patents, and the consequent expenditure of money by poor inventors, whose fees only serve to pay the salaries of the Patent Office examiners. The number of victims was less in the second year than in the first, but it is still extremely large. Out of 17,000 applications for patents made in 1884 no fewer than 7,000 became void through not being proceeded with, a fact which is painfully significant when we remember that the fee for securing the invention for the next three years is only £3. About forty per cent, therefore, of the inventions which the Act was framed to encourage prove to be not worth protecting for four years at the total cost of £4; and the fact remains that of substantial novelties which deserve and secure the privilege of protection there has been no increase at all proportionate to the decrease in the amount of preliminary and secondary fees. This is just what was to be expected. A patent to be worth having is worth as heavy a fee as is ever likely to be put upon it; and for the hypothetical chance of securing a sound invention from some person too poor to raise more than a sovereign at starting, we have tempted thousands of such men to spend their sovereigns for no advantage at all. Whatever may be said against high fees, they had certainly the effect of sobering the imagination and suggesting the expediency of caution.

Low fees, however, will probably be maintained, like many other questionable things that happen to savour of popularity. There would be less to say against them if they afforded any efficient guarantee; but, as was pointed out at the time, the preliminary examination for which the inventor pays his money insures him no sort of legal protection. The charge is not enough to cover a searching technical examination, and it might almost as well be dispensed with. In the later stages of patents that are proceeded with, amendments of specifications and the claims of opponents are adjudicated upon by the officials, as set forth in the Act; but this, too, is illusory, and, according to *The Times*, has created dissatisfaction on account of the incompetence of the examiners and the non-effective character of their decisions, whatever they may be. The Patent Office administrators have power to alter and amend; but not necessarily for the benefit of the patentee, whose claims may be upset in a court of law, notwithstanding, and perhaps because of, the very alterations made at the instance of the Patent Office. Either the decisions of the Patent Law officers ought to be final, or they ought not to be attempted at all.

One other inevitable consequence of the cheap patent has been a very large increase in the number of badly drawn up specifications. Litigation, which has always been the bane of popular Patent Laws, will, it is apprehended, be encouraged by the change in this country, as it has been in America. It may be too much to expect of the committee any drastic recommendation such as, if adopted, would give absolute security to a patentee when once his claims have been investigated and admitted. Nevertheless, our opinion remains unaltered that where patent laws exist ostensibly for the encouragement of invention, and not for purposes of revenue, it is the duty of the State to grant no privileges for a money consideration unless the grantor is satisfied they are for the public good, and will

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undertake to defend them against all comers. One thing at least we may demand of the Committee, that they will put an end to the issue of patents to foreign applicants who obtain them merely to prevent English industry working the inventions for its own benefit. A correspondent of *The Times* assures us that the foreign patentee can be compelled to grant licenses for working his invention here. But the process of law is cumbersome, and attended with some risk. All foreign patents taken out under the English laws should be represented by an English agent, who, for the purposes of the Act, ought to be treated as the principal. As matters stand at present, an alien patentee can reap all the advantages to which a native-born subject would be entitled, without conferring on the country any of those industrial benefits which patent laws are designed to promote.

MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As an early user of motors, dating back so far as 1874, and ever since, a few words on this subject may be acceptable, seeing how much space is being devoted to this topic in your journal at this moment. The conclusions to which I have come are the following:—

The essence of a good dynamo is the essence of a good motor. Each can be used in turn as generator and motor with efficiency, and if this is not the case the machine is to be condemned. My experiments run over at least twenty machines, and although the tests on this head have been rough, yet they are conclusive. I am able to test the capacities of dynamos to a nicety, but not so with motors, so my practice is to "run them to ground"—that is, keep putting work on till the current reaches the carrying power of the wire. The results are surprising. Some motors will do double the work of others, although made for generators of equal power, and in some instances by the same maker. But in all cases the best motor made the best generator.

The manufacturers' tests are valueless for the workshop, and this is what so many will not recognise. No doubt a continual strain on the brake gives a result for the laboratory, but in a workshop matters are very different, one machine after another is put on or taken off, and the motor is greatly jerked and strained. Some motors "tear away" one moment and are nearly "pulled up" the next. The commutator suffers heavily in consequence, as well as the motor itself and the generator. I believe had it not been for this motors would have crept into all manufactories.

To avoid these difficulties manufacturers have given great speeds to their motors as compared with their dynamos, and it is mainly in this respect that motors have till recently differed from dynamos, *i.e.* the armatures were wound to have lower resistance and more carrying power. By this device the great variations in speed were in a way mastered, when work was thrown on and off; but these motors are difficult to start properly, even with resistances, and they are not very satisfactory in other respects. Such principles are an attempt to make the motor do what the equivalent size in dynamos could do, and would be condemned if such speeds were necessary.

For myself, a successful motor is of immense importance, for all the work here is done by means of them.

Till recently none have been satisfactory on all points, and inconvenience was caused every few days by some new adjustment being required to one motor or another. I have lately added two Elwell-Parker motors, which are built on scientific principles, and nothing really novel about them; but the effect is marvellous, no running away, no sparking, start as easily as possible, they do the same work as before with half the current and far more steadily, they do not shake the house at points 50 yards from the motor—in fact, there is no vibration six inches off, so I am well satisfied. The chief points about each motor are these:—Very well constructed electrically, the centre of gravity is very low, a broad base to rest on, speed moderate (same or rather less than for corresponding size dynamo), the armature perfectly balanced. This latter is what gives more trouble than can be supposed if absent. Vibration is produced, which is conducted to shafting and machines, till everything in a workshop gets out of truth. All my pulleys are ruined through badly balanced motors, and nearly every one has been replaced. The want of balance is even reflected to the generator, because the current becomes vibratory in character "in time" to the motor.

I will not name the makers of these motors, but may say that they stand high in public estimation.

We have eight to ten motors running here, and depend upon them entirely, so that any perfect machine is welcomed. The Elwell-Parker motors referred to are 1 and 4 horse-power nominal, but give far more power; in fact, the 4 horse-power at half the current intended for maximum does more work than the motor displaced did at near maximum, *i.e.*, current actually used in the two cases was at 20 to 45 amperes at 100 volts in each case.

There has been a tendency in manufactories to use large motors, and to distribute by means of shafting. This is right enough for a steam engine, but for electromotors it is a mistake. It is fair to assume that from the steam engine to the latter 50 per cent. of the power is lost for electrical means of distribution. This seems bad, but no one considers the loss of power by the use of heavy shafting. I think it will be found 30 per cent. of loss is below the mark, for in factories shafting is not always so well attended to as it should be, and alignment right at first soon alters and is "out of mind."

Now, with a steam engine, it must always run the whole of the main shafting; but if a small motor is placed to every machine throughout the factory, only the machine itself need run, or with its countershaft if required, and at such moments only when this machine is in use and at any desired variation of speed, if arranged for this. It is far easier to switch a current on and off than to shift a belt, and the factory roof may be lighter in construction by the absence of countershafting and shafting, and this process is clearly much more economical.

I have conducted experiments of a ludicrous kind to show the economy, viz., a gas engine running a dynamo in the same shop as the machines with small motors, and this showed a saving in gas over running the same machines with the shafting which existed direct from the gas engine.

This was a rough test, but a practical one, for the shafting was of the most modern kind.

The only difficulty to contend with was to find a satisfactory motor which would run smoothly, not spark, and be efficient besides. This appears now to have been found. I dare say that some readers may think that I have the firm of Elwell-Parker on the brain, after my letter published in your sister journal last week; but it is not the case. The fact is that most of the leading and old established firms have plenty of work in hand, and at all times view new departures with suspicion and dislike, because of the expense of altering standards, tools, and templates; whereas a new company starts with all the experience of the old ones, and, not being tied down by precedent, starts fair to meet new exigencies, if the managers are clever people. And it is with such advantages that Messrs. Elwell-Parker have started, and they will no doubt "wake up" the old firms to "move on" likewise.—Yours, &c.,

DAVID SALOMONS.

Broomhill, Tunbridge Wells, Jan. 23, 1886.

THE ROSENTHAL GALVANOMETER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of January 22nd you speak of this instrument as an "addition" to the laboratory.

It can hardly have any claim to novelty, as galvanometers, with the mirrors outside the coils, and a long suspension, must have been in use for ten years at least, and I have made several myself during the past three years.

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This method of construction has several advantages over the old-fashioned "Thomson," and when made astatic, with coils round both needles, is wonderfully sensitive; for example: With an astatic galvanometer, resistance 3·2 ohms, mirror 40 centimetres from scale; ·0000001 ampere gave a deflection of from 10 to 20 millimetres, and that with a quick return to zero.

I have not yet adopted silver wire in lieu of copper for the coils. Really, is it worth while to multiply the cost of wire fifty or sixty times for the sake of a possible gain in conductivity of 1 or 2 per cent.? One cannot help admiring the enthusiasm of Herr Rosenthal.—Yours, &c.,

SYDNEY EVERSHED.

Kenley, Surrey, January 26th, 1886.

THE TELEPHONE IN LONDON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have been watching for some time to see if any of the subscribers to the United Telephone Company would ventilate their grievances in your paper. You have championed their cause on many occasions, and during the last few weeks have given the company a sharp reminder of the dangers of overhead wires. It is not, however, on this subject that I wish to address you, but on the matter of the general arrangements of the Telephone Company.

It seems to me that the subscribers to the United Telephone Company are the most easily pleased people on the earth. It is true that we have got so accustomed to being told that the number we require is "out of order," that we take little notice of that, but I contend the system is bad that regularly allows such things to happen. It is not once in a while only that we fail to get the subscribers we want, but I have been told in one day that five or six numbers, each situated in different parts of London, were out of order. This, however, is not the worst form of vexation that the subscribers have to put up with. We ring for a number. The answer comes in due course, "Out of order." We then spend a shilling or so in telegrams or employ a messenger, and when he is well started we find that our friends have managed to ring *us* up, and, to our surprise, inform us that "there is nothing wrong" with their instrument. The fact is the *employés* of the Telephone Company are getting as heedless of the subscribers' interests as the directors appear to be, and if there is any trouble whatever in getting a number, the exchange informs us it is "out of order."

What I have complained of here is repeatedly taking place, and I am sure many of the subscribers could confirm my assertions. I consider we spend two or three times as much on telegrams as we should do if the Telephone Company were efficiently managed. I have often asked firms with whom we do business to become subscribers, but they almost invariably answer that it would only be adding £20 a year to their expenses without diminishing their cost for telegrams. In this they are to a great extent right.

I account for the progress the telephone company has made in getting subscribers in London by the fact that the telephone is an invaluable invention, and recommends itself for use, but I deny that it has been of such service in London up to the present time as it might have been if properly managed.

For myself, I should be inclined to forgive the overhead wire system if only we could get a fair amount of attention, but if this is to blame for the many failures that occur, the sooner it is altered the better. If only a few of the many subscribers who are continually grumbling at the inattention they receive would take the trouble to publish their grievances, it is probable the Directors of the Company would go into the matter more carefully, and try to remedy some of the faults complained of.

I consider something ought to be done in this matter, and unless the United Telephone Company bestirs itself very soon many of the subscribers to their present system will either leave them altogether, or be ready to join any rival company that may be started. Trusting you will find space for this letter.—Yours, &c.,

London, January 27, 1886. SUBSCRIBER.

A CORRECTION.

Mr. H. Kingsford sends the following correction in his Paper, read before the Society of Telegraph-Engineers:—

$$\frac{\dfrac{a}{r+\dfrac{r''+R}{2}}}{2} = \frac{a}{c} = \text{current through fault.}$$

$$\frac{\dfrac{a}{r+\dfrac{r''+R}{2}}}{2} = \frac{a}{d} = \text{current through } x.$$

R_1 will equal $e - c$.

A NEW SOLUTION FOR ELECTRO-DEPOSITION OF METALS.*

BY G. GORE, LL.D., F.R.S.

The liquid employed was an aqueous solution of asparagine. It was not quite saturated, and consisted of about ·88 gramme of crystals of the substance, dissolved in 18·cc. of distilled water. The solution was faintly acid to test-paper, and was used at a temperature of about 70°C. Portions of this liquid were more or less saturated with different metallic oxides, and the resulting solutions electrolysed by currents from one to six voltaic couples, consisting of zinc and platinum in dilute sulphuric acid. The electrodes had usually one square centimetre of surface on each side.

Experiment 1.—·23 gramme of hydrated oxide of cadmium was mixed with about 20·cc. of the liquid; it did not all dissolve, and the solution was feebly alkaline. The mixture was electrolysed with an anode of cadmium and a cathode of copper. Adherent, white, reguline deposits of cadmium were easily obtained; no gas was set free at either electrode, and the anode remained clean and bright.

Experiment 2.—·28 gramme of zinc oxide was added to about 23·cc. of the liquid; the latter became alkaline. With a zinc anode and copper cathode, and a current from six cells, a moderately good deposit of metal was produced. No gas was evolved.

Experiment 3.—By using calcined magnesia in place of oxide of zinc, a current from six cells, and a magnesium anode, a film only was deposited upon the copper cathode, and that film evolved gas distinctly when wetted with dilute sulphuric acid. The amount of deposit was not increased by using a larger anode, a smaller cathode, and a more concentrated solution. Much gas was then evolved at each electrode. The mixture was alkaline to test paper.

Experiment 4.—·9 gramme of cupric oxide was partly dissolved to a blue liquid in 23·cc. of the solvent. With a copper anode and platinum cathode, a small amount of reguline metal was deposited by a current from six cells. Addition of a little ammonia to the solution decreased considerably the conduction resistance, but caused evolution of gas at the cathode during passage of the current, and the deposited metal to be soft and of a dark colour.

Experiment 5.—·1 gramme of dark red mercurous oxide was mixed with 21·cc. of the liquid. With electrodes of sheet platinum, a small amount only of mercury was deposited by the current from six cells. No gas was evolved. With yellow mercurous oxide the results were similar.

Experiment 6.—·33 gramme of oxide of silver was added to about 20·cc. of the asparagine liquid; the latter became

* Read before the Birmingham Philosophical Society, Jan. 21st, 1886.

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feebly alkaline. With an anode of silver and a cathode of platinum, and a current from one, two, or four cells, good deposits of white reguline silver were obtained. No gas was set free.

Cyanide of silver was insoluble in a hot solution of asparagine.

EXPERIMENTS ON MECHANICAL MOTORS FOR TRAMWAYS.*

BY CAPTAIN DOUGLAS GALTON, D.C.L., C.B., F.R.S.

The following is a portion of Captain Douglas Galton's paper—that portion, in fact, dealing more especially with electrical motors :—

In the electric tramcar the haulage was effected by means of accumulators. The car was of the ordinary type with two platforms. It was said to have been running as an ordinary tramcar since 1876. It had been altered in 1884 by raising the body about six inches, so as to lift it clear of the wheels, in order to allow the space under the seats to be available for receiving the accumulators, which consisted of Faure batteries of a modified construction. The accumulators employed were of an improved kind, devised by M. Julien, the under manager of the Compagnie l'Electrique, which undertook the work. The principal modification consists in the substitution, for the lead core of the plates, of one composed of a new unalterable metal. By this change the resistance is considerably diminished, the electromotive force rises to 2·40 volts, the return is greater, the output more constant, and the weight is considerably reduced. The plates being no longer subject to deformation, have the prospect of lasting indefinitely. The accumulators used were constructed in August, 1884.

The car, as altered, had been running as an electric tramcar on the Brussels tramways since October, 1884, till it was transferred to the experimental tramway at Antwerp. The accumulators had been in use upon the car during the whole of this period, and they were in good order at the end of the experiments, that is to say, when the Exhibition closed at the end of October, 1885. The accumulator had forty elements, divided into four series, each series communicating, by means of wires fixed to the floor of the car, with commutators which connected them with the dynamo used as a motor. There were two sets of these batteries or accumulators, one of which was being charged in the shed whilst the other was in use. The exchange required ten minutes, including the time for the car to go off the tramway into the shed and return to the tramway. This exchange took place after every seven journeys. Therefore, the two batteries would have sufficed for working the car over a distance of about 42 miles during 16 hours.

It may be observed that the first service in the morning would be performed by means of the accumulators charged during the afternoon and evening of the previous day. Each element of a battery was composed of 19 plates, of which 9 were positive, 4 millimetres thick, and 10 negative, 3 millimetres thick. Each positive plate weighed 1·44lb., of which about 25 per cent. consisted of active material. Each negative plate weighed nearly 1lb., of which one-third consisted of active matter. The weight of the metallic part of the battery amounted, therefore, to 1,846lb.; and the whole battery, including the case and the liquid, amounted to 2,464lb., which contained 499lb. of active matter, or about 20·25 per cent. The four cases in which the battery was contained were so arranged as to divide the weight equally between the wheels. Two commutators enclosed in a box were placed on the platforms at the two ends of the carriage, so as to be available for moving in either direction. The accumulators were divided into four series of ten double elements, which, by means of the commutators, could be united under four combinations, viz:—

1st	4 series in quantity	1 in tension.
2nd.........	2 series in quantity	2 ,,
3rd	——	3 ,,
4th	——	4 ,,

Finally, a fifth movement united the four series in quantity, coupling them on each other, and putting the dynamo out of circuit, thus restoring equilibrium. When in a state of repose the handle was so arranged as to keep this latter switch turned on. The accumulators were arranged for charging in two series united in quantity, each containing twenty double elements. The charge was effected by a Gramme machine, worked by a portable engine. Each of these series received its charge during seven hours for the ordinary service of the car, and during nine hours for the accelerated service. The accumulators on the car actuated a Siemens dynamo, acting as a motor, such as is used for lighting, having a normal speed of 1,000 revolutions, fixed on the frame of the carriage. The motion was conveyed from the pulley on the dynamo by means of a belt passing round a shaft fixed on movable bearings to regulate its tension, and thence to the axles by means of a flat chain of phospor bronze. The chain was adopted as the means of moving the axle, on account of its simplicity and facility of repair by unskilled labour. The speed was fixed at four metres per second (which corresponds with a speed of nearly nine miles per hour), for 1,000 revolutions of the dynamo; and it was regulated by cutting a certain number of the accumulators out of circuit, instead of by the device of inserting resistances which cause a waste of energy. By breaking the circuit entirely the motive power ceased, and the vehicle might either be stopped by the brakes or allowed to run forward by gravity, if the road were sufficiently inclined. The reversal of the motor was effected by means of a lever which reversed the position of the brushes of the dynamo. The dynamo could be set in motion, and the carriage worked from either end, as desired. The handle to effect this was movable, and as there was only one handle and this one was in charge of the conductor, he used it at either end as required.

It should be mentioned that the car was lighted at night by two incandescent lamps, which absorbed 1·5 ampere each; and the brakes also were worked by the accumulators. The weight of the tramcar was 5,654lbs.; the weight of the accumulators was 2,460lbs.; the weight of machinery, including dynamo, 1,232lbs. The car contained room for fourteen persons inside and twenty outside. Under the conditions of the competition the car was required to draw a second car occasionally. The jury made special observations upon the work required to move the car between the 20th September and 15th October, 1885. Seals were attached to the accumulators. Moreover, from the 27th of September, after each charge, seals were placed on the belts from the steam engine to prevent any movement of the Gramme machine, so that there could be no charges put into the accumulators beyond those measured by the jury. The instruments used for measuring were Ayrton's ampere meter and Deprez's volt meter, which had been tested in the Exhibition by the Commission for Experiments on Electrical Instruments, under the presidency of Prof. Rousseau. Besides this Siemens electro-dynamometer and Ayrton's voltmeter were used to check the results; but there was no practical difference discovered. During the period of charging the accumulators, the intensity of the current and the electromotive force was measured every quarter of an hour, and thence the energy stored up in the battery was deduced. It may be mentioned that the charge in the accumulators, when the experiments were commenced, was equal in amount to that at their termination.

An experiment was made on 21st October to ascertain, as a practical question, what was the work absorbed by the Gramme machine in charging the accumulators. The work transmitted from the steam engine was measured every quarter of an hour by a Siemens dynamometer, at the same time the intensity of the electromotive force given out by the machine, as well as the number of the revolutions it was making, was noted. It resulted that for a mean development of 4 mechanical horse-power, the dynamometer gave into the accumulators to be stored up 2·28 electrical horse-power, or 57 per cent. The intensity varied between 25·03 and 23·51 amperes during the whole time of charging. Of this amount stored up in the accumulators a further loss took place in working the motor; so that from 30 to 40 per cent. of the work originally given out by the steam engine must be taken as the utmost useful effect on the rail. It was estimated that to draw the carriage on the level ·714 horse-power was required, or if a second carriage was attached, ·848 horse-power would draw the two together. This would mean that, say, 2 horse-power on the fixed engine would be employed to create the electricity for producing the energy required to draw the carriage on the level. The electric tramcar was quite equal in speed to those driven by steam or compressed air, and was characterised by its noiselessness and by the care with which it was manipulated.

Assuming the car by itself cost the same as an ordinary tramcar, the extra cost relatively to other systems was stated as being, according to the following figures, viz.:—The Gramme machine cost £48, the motor £208, and the accumulators 2·25 francs per kilogramme (10d. per pound). To these must be added the cost of erection, and of switches for manipulating the current, as well as the proportion of the cost of a fixed engine to create the electricity.

* * * * * * *

The original programme of the conditions which were laid down in the invitation to competitors, as those upon which the adjudication of merit would be awarded, contained twenty heads, to each of which a certain value was to be attached; and, in addition to these special heads, there were also to be weighed the following general considerations, viz :—*a.* The defects or inconveniencies established in the course of the trials. *b.* The necessity or otherwise of turning the motor, or the carriage with motor, at the termini. *c.* Whether one or two men would be required for the management of the engine.

As regards these preliminary special points, the compressed air motor, as well as the Rowan engine, required to be turned for the return journey, whereas the other motors could run in either direction. In regard to this, the electric car was peculiarly manageable, as it moved in either direction, and the handle by which it was managed was always in front, close to the brake. The carriage was the only one which was entirely free from the necessity of attending to the fire during the progress of the journey, for even the compressed air engine had its small furnace and boiler for heating the air. Each of the motors under trial was managed by one man.

The several conditions of the programme may be conveniently classified in three groups, under the letters A, B, C. Under the letter A have been classed accessory considerations, such as those of safety and of police. These are of special importance in towns. But their relative importance varies somewhat with the habits of the people as well as with the requirements of the authorities; for instance, in one locality or country conditions are not objected to, which in another locality are considered entirely prohibitory. The conditions under this head are :—

1. Absence of steam. 2. Absence of smoke and cinders. 3. Absence, more or less complete, of noise. 4. Elegance of aspect. 5. The facility with which the motor can be separated from the carriage itself. 6. Capacity of the brake for acting upon the greatest possible number of wheels of the vehicle or vehicles. 7. The degree to which the outside covering of the motor conceals the machinery from the public, whilst allowing it to be visible and accessible in all parts to the engineer. 8. Facility of

* Results of Experiments on Mechanical Motors for Tramways Made by the Jury on Railway Appliances at the Antwerp Exhibition. (From the *Journal of the Society of Arts* for January.)

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communication between the engineer and the conductor of the train. In deciding upon the relative merits of the several motors, so far as the eight points included under this heading are concerned, it is clear that, except possibly as regards absence of noise, the electrical car surpassed all the others. The compressed air car followed, in its superiority in respect of the first three points, viz., absence of steam, absence of smoke, and absence of noise; but the Rowan was considered superior in respect of the other points included in this class. Under the letter B have been classed considerations of maintenance and construction. 9. Protection, more or less complete, of the machinery against the action of dust and mud. 10. Regularity and smoothness of motion. 11. Capacity for passing over curves of small radius. 12. The simplest and most rational construction. 13. Facility for inspecting and cleaning the interior of the boilers. 14. Dead weight of the train compared with the number of places. 15. Effective power of traction when the carriages are completely full. 16. Rapidity with which the motor can be taken out of the shed and made ready for running. 17. The longest daily service without stops other than those compatible with the requirements of the service. 18. Cost of maintenance per kilometre. (It was assumed, for the purposes of this sub-heading, that the motor or carriage which gave the best results under the conditions relating to paragraphs 9, 10, 12, and 13, would be least costly with repairs.)

As regards the first of these, viz., protection of the machinery against dirt, the machinery of the electrical car had no protection. It was not found in the experiments at Antwerp that inconvenience resulted from this; but it is a question whether in very dusty localities, and especially in a locality where there is metallic dust, the absence of protection might not entail serious difficulties, and even cause the destruction of parts of the machinery. In respect of the smoothness of motion and facility of passing curves, the cars did not present very material differences, except that the cars in which the motor formed part of the car had the preference. In the case of simplicity of construction, it is evident that the simplest and most rational construction is that of a car which depends on itself for its movement, which can move in either direction with equal facility, which can be applied to any existing tramway without expense for altering the road, and the use of which will not throw out of employment vehicles already used on the lines; the electric car fulfilled this condition best, as also the condition numbered 13, as it possessed no boiler.

In respect to No. 14, viz., the ratio of the dead-weight of the train to passengers, if we assume 154lb. as the average weight per passenger, the following is the result in respect of the three cars in which the power formed part of the car:—

$$\text{Electric car} \ldots\ldots \frac{9,350\text{lb.}}{154 \times 34} = 1 \cdot 78.$$

$$\text{Rowan} \ldots\ldots\ldots\ldots \frac{15,950\text{lb.}}{154 \times 45} = 2 \cdot 30.$$

$$\text{Compressed air} \ldots \frac{22,000\text{lb.}}{154 \times 56} = 2 \cdot 55.$$

The detached engines gave, of course, less favourable results under this head.

Under head No. 15 the tractive power of all the motors was sufficient during the trials, but the line was practically level, therefore this question could only be resolved theoretically, so far as these trials were concerned. As regards the rapidity with which the motors could be brought into use from standing empty in the shed, the electric car could receive its accumulators more rapidly than could the boiler for heating the exhaust of the compressed air car be brought into use. As regards the steam motors, the following were the results from the time of lighting the fires:—

The Rowan—

In 34 minutes .... 3 atmospheres.
36 ,, ... 4 ,,
(At this pressure the vehicle could move.)
40 ,, ... 8 ,,

The Wilkinson—

In 35 minutes .... 2 atmospheres.
40 ,, ... 4 ,,
44 ,, ... 6 ,,
47 ,, ... 8 ,,

The Krauss machine required two hours to give six atmospheres, which was the lowest pressure at which it could be worked. The results under No. 17, viz., the fewest interruptions to the daily service, class the motors in the following order:—Krauss, electric, Rowan, Wilkinson, compressed air. The chief cause of injury to the compressed air motor arose from the carelessness of the drivers, who allowed the steam boiler to be burnt out. Unfortunately, these drivers were new to the work. Under the letter C are classed considerations of economy in the consumption of materials used for generating the power necessary for working.

19. Minimum consumption of fuel (either coke or coal), in proportion to the number of kilometres run, and to the number of places, assuming for the seats a width of at least sixteen inches for each person seated.

It must be borne in mind that the conditions of the competition required that a second car should be periodically drawn by the motor, and that the calculations which follow include the total number of miles run, the total amount of fuel, &c., consumed; and the total number of passengers which could be conveyed by each motor during the total time that the experiments were being carried on.

20. Minimum consumption of oil, of grease, tallow, &c. (the same conditions as in No. 19).

In addition to these considerations, it was thought useful to investigate the quantity of water consumed in the case of these engines which used steam. The experiments made on this point showed, as the consumption of water:—

	Gallons per mile.
Rowan	·75
Compressed air	1·06
Wilkinson	5·89
Krauss	6·52

Thus, owing to the large proportion of water returned from the condenser to the tanks, the Rowan actually used less water than the compressed air engine.

Table I. / **Table II.**

Description of motor.	Total number of train miles run.	Total consumption of fuel.	No. of lbs. per train mile.	No. of places indicated on the cars, per mile run.	Consumption of fuel.	No. of lbs. of fuel consumed per places indicated per mile run.
		lbs.			lbs.	
Electric	2,358·9	14,786·	6·16	80,203·5	14,786·	·18
Rowan	2,616·9	14,498·	5·42	148,399·6	14,498·	·09
Wilkinson	2,473·3	22,000·	8 82	119,085·1	22,000·	·18
Krauss	2,457·8	22,726·	9·10	108,983·9	22,726·	·20
Compressed air.	2,259·1	90,420·	39·48	128,189·3	90,420·	·69

Table III. / **Table IV.**

Description of motor.	No. of seats per mile run.	Consumption of fuel.	No. of lbs. of fuel consumed per seat per mile run.	Total number of miles run.	Total consumption of oil, tallow, &c.	Consumption of oil, tallow, &c., per train mile run.
		lbs.			lbs.	
Electric	61,591·2	14,786·	·23	2,358·9	99·0	·038
Rowan	135,928·8	14,498·	·10	2,616·9	106·7	·038
Wilkinson	93,965·6	22,000·	·23	2,473·3	255·4	·101
Krauss	86,039·9	22,726·	·25	2,457·8	188·5	·073
Compressed air.	132,732·7	90,420·	·66	2,259·1	585 2	·255

As regards the figures in these tables, it is to be observed that the consumption of fuel for the electric car is, to a certain extent, an estimate; because the engine which furnished the electricity to the motor also supplied electricity for electric lights, as well as for an experimental electric motor which was running on the lines of tramway, but was not brought into competition.

Conclusion.

The general conclusion to which these experiments bring us is that, undoubtedly, if it could certainly be relied upon, the electric car would be the preferable form of tramway motor in towns, because it is simply a self-contained ordinary tramcar, and in a town the service requires a number of separate cars, occupying as small a space each as is compatible with accommodating the passengers, and which follow each other at rapid intervals. But the practicability and the economy of a system of electric tramcars has yet to be proved; for the experiments at Antwerp, whilst they show the perfection of the electric car as a means of conveyance, have not yet finally determined all the questions which arise in the consideration of the subject. For instance, with regard to economy, the engine employed to generate the electricity was not in thoroughly good order, and from its being used to do other work than charging the accumulators of the tramcar, the consumption of fuel had to be to some extent estimated. In the next place, the durability of the accumulators is still to be ascertained; upon this much of the economy would depend. And in addition to this question, there is also that of the durability of parts of the machinery if exposed to dust and mud. After the electric car, there is no question but that, at the Antwerp Exhibition, the most taking of the tramway motors was the Rowan, which was very economical in fuel, quite free from the appearance of steam, and very convenient and manageable. The economy of the Rowan motor arises in a large degree from the extent of its condensing power, by means of which a considerable supply of warm water is constantly supplied for use in the boiler, and, consequently, the quantity of water which has to be carried is lessened, and the fuel is economised. Independently, however, of its convenience as a motor for tramways in towns, the Rowan machine has been adapted on the Continent to the conveyance of goods as well as passenger traffic on light branch railways, and fitted to pass over curves of 50ft. radius, and up gradients of 1:10. In England, with our depressed trade and agriculture, there is a great want in many parts of the country of cheap means of conveyance from the railway stations into the surrounding districts; such a means of conveyance might be afforded by light railways along or near the road-side, the cost of which would be comparatively small, provided that the expensive methods of construction, of signalling, and of working, which have been required for main lines, and which are perfectly unnecessary for such light railways, were dispensed with. It is certain that this question will acquire prominence as soon as a system of local government has been adopted, in which the wants of the several communities have full opportunity of asserting themselves, and in which each local authority shall have power to decide on those measures which are essential to the development of the resources of its own district, without interference from a centralised bureaucracy.

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DISCUSSION.

Mr. PREECE, F.R.S., said he was a juryman at the Antwerp Exhibition, and though his official duties did not require him to inspect and report upon these tramcars, he took every possible opportunity of examining them, and, being an electrician, of travelling backwards and forwards on the electric car. He was delighted to find that the anticipations he formed, at an early period of the Exhibition, had been fully borne out by what Captain Galton had said. As an electrician, he had seen very great difficulties in carrying out a system of tramways worked by electricity; but, like all other difficulties, experience and study succeeded in removing them, and he had the greatest confidence in the future use of electricity for this purpose, whether applied directly or by the aid of accumulators. There was a great want of confidence in this latter system, the reason for which was not hard to discover, because they were thrust on the world long before either it was ready to receive them or they were properly developed. One of the first places in which the tide began to turn was in the Society of Arts. Some time back they had succeeded in lighting the hall by means of accumulators, and all present could see with what absolute steadiness the light was maintained. Captain Galton, at the end of the paper, said that undoubtedly, if it could be relied on, electricity would be the best motor for tramways; and that was the way in which everyone spoke of it. But there was no power on earth used for the service of man which could be so certainly relied on as electricity. He had no doubt, however, that we should yet live to see in London and the suburbs the Antwerp experiments repeated on a much larger scale.

Mr. A. RECKENZAUN said this was one of the most interesting and practical papers ever read on the subject of the mechanical propulsion of tramcars, but it would have been still more useful had the experiments been carried out on a line presenting more difficulties. It was very easy to travel on a level line, but very difficult to travel on an incline. For instance, if it required 2 horse-power on the level, it would take a 4 horse-power to go at the same speed up a gradient of 1 in 75, 6 horse-power for a gradient of 1 in 37, and 8 horse-power for 1 in 25, which was not very serious after all. Again, the sharpest curve on the line at Antwerp was only of a radius of one chain, and he was rather surprised it was not made sharper. He had recently been running a car in Berlin, where he had received much more encouragement than in London, and he believed a fair amount of business would be done there before any start was made in England at all. There, one curve was 11 metres radius, and there were several of 15 metres.

Mr. W. R. ROWAN could not agree with the two previous speakers. As far as he could gather the contest at Antwerp was really between two combined cars, the electric car and the steam car which he had designed. Having been there some eight or ten weeks, he could bear testimony to the great care and trouble taken by the jury over this question. There was no doubt that the most taking car was the electric motor, but the whole question from the first hinged on one word—economy; and the question would turn out to be, which was most economical, steam used directly in driving the car, or to produce electricity or compress air, which should then drive it? There were four main difficulties which he thought it would take electricians some time to get over. The first was the transmission of the power. The second difficulty was that of the accumulators; would they really last if knocked about daily in a tramcar? The trial at Antwerp gave very little information on that point, being short, straight, and level, so that they only had to be charged once a day. The third difficulty was the charging of the accumulators. In running up steep grades, and with grooved rails, which added greatly to the friction, he believed the accumulators would have to be charged five times a day, which would be a practical difficulty. Lastly, if all these difficulties could be overcome, he doubted if they could work as cheaply as with steam direct, seeing that only 25 to 40 per cent. of the power would be utilised.

Mr. B. DRAKE said there were one or two points in connection with the Electric Power Storage Company, which he represented, which he should like to mention. They not only used accumulators at their own works, but had supplied them for trial elsewhere, and in practical working it was found that, giving them the full charge, the efficiency in amperes was 75 per cent., and beyond that the loss in energy, expressed in watts, depended on the time at disposal to discharge them.

Mr. M. HOLROYD SMITH used electricity direct, and, therefore, there was no loss through the accumulators. The great question with regard to using electricity direct for street purposes was how to do it with safety to the public. By conveying the electricity underground, and having a means of communicating with it in the car, it was possible to utilise it without any danger either to the public or the traffic.

PHYSICAL SOCIETY.—January 23rd.

Prof. GUTHRIE, President, in the chair.

The following communications were read:—A note on the paper by Prof. W. Ramsay and Dr. S. Young, on "Some Thermodynamical Relations," by Prof. W. E. AYRTON and Prof. JOHN PERRY. The authors, after referring in the highest terms to the careful experimental work of Messrs. Ramsay and Young in their investigation upon "Some Thermodynamical Relations," the results of which were communicated to the society at its last meeting, show that the four laws stated in their paper are in reality only one, since if any one of them is assumed the remaining three may be deduced from it. Hence it is sufficient to examine only one, and of the four the third is in the form that can be most readily tested. This law, the statement of which is, that for all substances at any given pressure the product $t\frac{dp}{dt}$ is constant, p being the pressure and t the absolute temperature of saturated vapour at that pressure, is represented mathematically thus:—

$$t\frac{dp}{dt} = \phi(p) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$\phi(p)$ being a function of the pressure, independent of the substance. Writing this equation

$$\frac{dp}{\phi(p)} = \frac{dt}{t}$$

and integrating, we get

$$t = a\psi(p) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$\psi(p)$ being also a function of the pressure only, and a a constant depending only upon the substance employed. It is in this form that the authors have examined the third law. If true, it follows at once from (2) that the ratio of the temperatures of two saturated vapours to one another at any pressure is the same as the ratio at any other pressure. It is seen, however, either by reference to Regnault's numbers or Rankine's formula

$$\log p = d - \frac{\beta}{t} - \frac{\gamma}{t^2} - \ldots\ldots$$

an expression based upon his molecular theory, and which, as remarked by one of the authors at the last meeting, agrees with Regnault's results with remarkable closeness, that this ratio is far from constant. The authors are therefore compelled to conclude that the expressions given by Prof. Ramsay and Dr. Young must not be regarded as absolute laws.

A note on the paper, by Prof. J. W. Clarke, on the "Determination of the Heat Capacity of a Thermometer," by Mr. A. W. CLAYDEN. The author has applied a correction to an expression given by the late Prof. J. W. Clarke, for measuring the heat capacity of a thermometer, in a paper communicated to the Society at a previous meeting (April 25, 1885.) Prof. Clarke's expression was affected by the mercury not entirely filling the bulb and stem of the thermometer. The corrected expression obtained by the author is

$$V_1 = \frac{V(s - s_2)}{s_1 - \frac{s_2(1+\beta t)}{1+at}}$$

s, s_1 and s being the mean densities of the instrument, mercury, and glass respectively, β and a the coefficients of voluminal expansion of mercury and glass; V and V_1 the volumes of the instrument and of the mercury.

"Note on some Organic Substances of High Refractive Power," by Mr. H. G. MADAN. In the course of some correspondence respecting M. Bertrand's polarising prisms, the author was informed that the cement used was napthyl-phenyl-ketone dibromide. He has consequently prepared specimens of the ketone, and subjected them to optical examination. The ketone is a thick yellow oil, boiling at a temperature near the boiling point of mercury; it appears to be a very stable, neutral, and harmless substance like Canada balsam, but unfortunately it does not appear to be capable of hardening, and hence is not by itself adapted for a cement. Its refractive index for the D line is 1·666, higher than that of carbonic sulphide, while its dispersive power is approximately the same as that of that substance. The author has made the bromide of the ketone referred to above; but it seems liable to decompose with formation of hydro-bromic acid, which acts upon the spar. Mr. Madan also exhibited a specimen of metacinnamene, a highly refracting glass-like solid obtained by the action of light or heat upon cinnamene. This substance possesses a retractive index of 1·592 for the D line, and would make a valuable cement if it showed a firm adhesiveness for glass.

The PRESIDENT exhibited and described an instrument he had made in the course of an acoustical investigation upon which he had been engaged. It is a musical instrument similar in principle to the harmonicon. In the case of the harmonicon the rectangular plate is usually supported by strings passing through the nodes, but the author wished to make an instrument that could be "bowed." The nodes are not absolute positions of rest, the particles at them describing curves having cusps pointing outwards. The plan adopted was to solder two springs to the plate, which was of brass, the points of attachment being slightly outside the nodes, and the springs being such as to give the same fundamental note as the plate. The other ends of the springs were attached to the mouth of a resonator, whose fundamental note was also that of the plate. The plate, when struck or bowed, gave a tone very like that of a tuning fork, and, in a discussion that followed, Prof. S. P. THOMPSON suggested the possible use of these instruments as a substitute for a series of forks, the cost of a complete set of which often placed them beyond the reach of the student. Prof. McLEOD suggested that the springs should be tuned to the octave of the plate instead of to its fundamental, and that they should have a slightly different form.

THE PERSIAN GULF TELEGRAPH CABLE.

The following report to the Under Secretary of State for India, by Sir J. U. Bateman-Champain, R.E., K.C.M.G., giving details of the operation of laying the new cable from Bushire to Cape Jask, in the Persian Gulf, will be found interesting:—

Indo-European Government Telegraph Department,
Karachi, Dec. 1, 1885.

On the 29th of April I received instructions from the Right Honourable the Secretary of State to take the necessary steps for obtaining tenders for

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the manufacture of a new cable to be laid between Jask and Bushire, and also to arrange in due time for its shipment and submersion. On the 18th of June the manufacture was commenced at Silvertown. The work went on smoothly and satisfactorily under the electrical supervision of Messrs. Clark, Forde, and Taylor, who undertook to maintain careful and constant testing at the factory. After arranging for the making of the cable, the next most important consideration was the engagement of ships in which to convey it to the Gulf and there safely deposit it at the bottom of the sea.

We calculated that the expedition would last 100 days from the time the ships left Silvertown till their return to that place. We required more than 3,000 tons gross tonnage, and it was essential that the ships should be fitted with cable tanks, paying-out machinery, testing rooms and appliances, a steam launch, and other apparatus. Our own cable hands and Lascars at Karachi would not be sufficiently numerous for the work, and therefore it was made a condition in the charter party that the vessels should carry and place at our disposal a certain number of experienced cable hands, to whom, as well as others of the ships' companies directly employed in the operations, a gratuity of half a month's pay should be granted by Government on the successful completion of the work.

Eventually the two cable ships, "Dacia" and "International," the property of the India Rubber and Gutta Percha Telegraph Works Company, were engaged for a lump sum of £17,500. Twenty-one days after the arrival in India were to be given for the completion of the work, after which demurrage, at the rates of £100 per diem for the "Dacia" and £75 for the "International," was to be paid by the Government. For the important duties of testing the cables on the outward voyage I sent for Mr. Harrison (an acting assistant superintendent in my department) from Karachi, and placed him in charge on board the "International." Mr. F. Maclean, a superintendent of the Indian Department, returning from furlough, volunteered to test the cable on the "Dacia." As regards the loading of the vessels, the best way in which to distribute the cable in the different tanks, and the condition of the cable machinery, &c., we took the professional opinion of Mr. F. C. Webb, an electrical engineer of great experience, who was in former years employed by the Government of India on the Persian Gulf cables, and his reports were of great use.

The cable was all on board by September 20; Messrs. Clarke, Forde, and Taylor's certificate was thoroughly satisfactory; and on September 19 I decided that the "Dacia," with Sir Henry Mance, myself, and others on board, carrying 339 miles (1,260 tons) cable, 350 tons coal, and 140 tons stores, should sail from Greenhithe for Karachi on October 6. The "International," with Mr. Harrison in charge, and 191 miles (735 tons) cable, 260 tons coal, and 90 tons stores on board, was to sail three days later, direct for Jask.

Complete information as to our plans and instructions as to local preparatory action had been previously supplied to Mr. Ffinch, and through him to Captain Bishop, commanding the departmental cable vessel, the "Patrick Stewart." The last-named ship was to join us either at Karachi or Jask. We reached Karachi on the morning of November 10, and, after taking on board Mr. Ffinch, several clerks, foremen, and cable hands, European and native, and a considerable amount of cable stores and paraphernalia, we sailed again on the evening of the 11th for Jask. We began rather badly, the "Dacia's" steam launch "carrying away" while being hoisted, and flinging a man overboard. Life buoys were thrown to him and he was promptly picked up, but we were compelled to leave the sunk launch, buoying the spot so that she could be recovered heareafter. On the morning of November 14 we anchored off Jask, and were pleased to find the "International" awaiting us, she having arrived direct from Aden the previous evening. The "Patrick Stewart" steamed in from the Gulf four or five hours after ourselves. Mr. Harrison reported that the cable under his charge was, like our own, in perfect order.

Next morning, the 15th, the actual work of laying the third Persian Gulf began. At this moment all communication with Europe by our line was suspended, owing to a break in the 1869 india rubber cable close to Jask. The "Patrick Stewart" promptly repaired this, and at the same time the "International" began landing our new Jask shore end. By means of balloon buoys, and thanks to the magnificently calm weather, the heavy end from ship to shore, half a mile or so long, was safely laid in the incredibly short space of thirteen minutes. At 12:30 we commenced paying out from the "International" towards Bushire at a speed of about four knots an hour. The "Patrick Stewart" led the way, and the "Dacia" followed us, taking frequent soundings for our information and guidance hereafter. The repair of the india rubber cable was very lucky, as we were now in direct telegraph communication, not only with Jask but also with our goal, Bushire, and were thus kept acquainted with the state of the weather ahead.

On the morning of the 17th we had laid the 191 miles of cable from the "International" and buoyed the end. We transferred ourselves, our staff, and stores to the "Dacia," and bade good-bye to the other vessel, which by 10:30 a.m. had finished all she had to do for us and was under way for Karachi. After splicing on to the buoyed end of the cable we started afresh for Bushire. On the 18th the sea was somewhat rough, but so smoothly and well did the machinery work that no anxiety whatever was experienced, and we were able to pay out at a rate of over six knots per hour. That night, it seems, the "Patrick Stewart" hardly made sufficient allowance for current, and led us a few miles further south than the course intended. This was somewhat unfortunate, as the soundings showed that we passed over a shoal which we meant to avoid. On this patch we laid the cable in fifteen fathoms depth instead of forty, and there is some cause for fearing that the irregularity of the bottom may in course of years tell on the cable and cause a break. It may be desirable to lift and relay this short length, at some future date, a work which the "Patrick Stewart" can perform with ease at any time.

Early on the 20th we had laid the whole line to within six miles of Reshire, the site of the Bushire telegraph offices. The main cable was cut and buoyed, and by 9 p.m. the shore end was laid and joined up in the cable office and the work was satisfactorily finished. I believe no smarter piece of cable laying has ever been done. Thanks to Sir Henry Mance's admirable foresight and powers of organisation, and thanks to the energy and devotion of our departmental officers and men engaged, more than 500 miles of cable (sanctioned only in the latter end of spring) have been laid in perfect order, and at an extraordinarily small cost, punctually by the date foretold. We are thankful to have been favoured by the weather, and, with the exception of the little accidents noted above (which did not interfere with the work), no difficulty, no unpleasantness—in short, no hitch, occurred from first to last.

We arrived at Karachi on November 29, and relinquished control of the "Dacia" on the 1st of December, having employed the ship for a little less than the 21 days allotted for our task.

I now beg to be allowed to repeat that to Sir Henry Mance is due the credit of what, I trust, will be admitted has been a thoroughly successful expedition, but I must say that the other gentlemen engaged performed their very important functions with the greatest zeal and assiduity. The staff was divided into two watches, neither being day or night more than four hours at a time off duty. The records and observations kept during the laying will be fully described in the engineer's report, which I think ought to be printed when we return to London. Messrs. Possman and Sealy had charge of the watches, and were untiring in their exertions. They were most ably assisted by Messrs. Harrison, Allen, Andrews, and Hopkins, of this department, while records of the soundings, of the position of the paying-out ships, and the amount of cable expended at any particular minute, with a variety of other useful details, were, under Messrs. Possman and Sealy's superintendence, kept with admirable precision and care by Mr. Twisaday, of my London office, and Mr. Bailey, an *employé* of the India Rubber and Gutta Percha Company. Four or five junior clerks were told off for day and night signalling by steam whistle, flags, or hand lamps to the "Patrick Stewart. Mr. Brown and the foremen and cable hands under his immediate charge likewise carried on their share of the work as well as possible. I must also express my warmest thanks to Mr. Pfinch, the Persian Gulf division, for the accuracy and completeness with which everything at Karachi and at the Gulf stations had been prepared for us beforehand. Mr. Ffinch accompanied the expedition, and co-operated with Sir Henry Mance and myself in the most cordial and energetic spirit.

Lastly, I desire to record my warm appreciation of the conduct of the officers and men in the employ of the India Rubber and Gutta Percha Company on both the ships "Dacia" and "International." Captain Tindall, of the latter vessel, and Captain Wilson Barker, of the former, helped us in every possible way, and nothing was omitted which could assist in making the voyage out agreeable and the cable laying successful. Both ships were, as is the custom with the company, under the absolute orders and control of Mr. Theophilus Smith, an electrical engineer of experience and ability, to whom, for his great kindness and constant attention, we all feel sincerely grateful. I can truly state that from the day we embarked at Greenhithe till we finally left the "Dacia" this day, there has been, thanks in a great measure to Mr. Smith's tact and consideration, no dispute or difference of opinion of any sort between the officers of the Government and those of the India Rubber and Gutta Percha Company.

COMPANIES' MEETINGS & REPORTS.

The Eastern Telegraph Company (Limited).

The twenty-seventh half-yearly ordinary general meeting of this Company was held on Thursday, January 21st, 1886, under the presidency of John Pender, Esq.

The SECRETARY read the notice convening the meeting, and the minutes of the last general meeting and the report having been taken as read,

The CHAIRMAN said: Gentlemen, although the report which you have all no doubt had the pleasure of perusing is as full and complete as it is almost possible to make any report submitted to a body of shareholders, I am anxious, and so are my colleagues, at all times that the very fullest information which we possess should be given to the shareholders at these half-yearly meetings. I have, therefore, some detailed remarks to make which go more or less to confirm the report and to explain it more in detail. The revenue for the last six months, ending the 30th September, 1885, amounted to £331,420, against £309,569 in the corresponding period of last year, or an increase of £21,851. The return on our investment in the Eastern and South African Company shows a falling off for the half year of £1,950, the dividend having been at the rate of 7 per cent. instead of 8 per cent. On the other hand, our return from the Black Sea Company shows an increase of £771. I am pleased to observe that our Indian traffic, which has been stationary for some years, shows some signs of revival, but the main increase of traffic in the six months' accounts which we are now considering is owing to the military operations in Egypt and Burmah. Our Australian, China, and Tonquin

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traffic was very good during the greater portion of last year, but I may say that since the middle of December there has been a considerable falling off. We may, however, hope that the reduction is only temporary, and that there will before long be a general expansion of business from which the Company will certainly benefit. The total working expenses amounted to £86,935, against, in the corresponding period of 1884, £84,907, being an increase of £1,928. The principal items, showing increases and decreases, are as follows:—General expenses in London, a decrease of £2,881; salaries and wages, office expenses, and stationery, and printing show increases. These items are directly affected by the increase of business, and the gradual growth of our system. Advertising, repairs, and renewals of furniture, and law charges show decreases. The working expenses at stations amount to £60,497, against £58,009, or an increase of £2,488. The details are as follow:—Salaries and wages, as compared with September, 1884, show an increase of £3,568, but as compared with the last half-year the increase is only £1,930. We have opened out new stations at Parliament-street, Westminster, and Perim in the Red Sea. There is also a full six months' working of Katacolo and Patras, against two months of the former and one month of the latter during the same period of 1884. There has also been an increase in the number of clerks at stations where the pressure of business is greatest. I may state that the total number of the staff at September, 1884, was 526, and at September, 1885, the number was 562, being an increase of 36. Promotions have also been made in certain cases where high proficiency and length of service have entitled them to the recognition of the Board. Repairs and renewals of furniture show an increase of £790. The principal expenditure under this head is at Gibraltar, the cause of which I fully explained at the last meeting. There are also included the first charges for fitting up the new stations to which I have just referred. Repairs to stations show an increase of £660. We have made considerable sanitary improvements at our Training School at Porthcurno, and repairs have been effected to our property at Carcavellos, Alexandria, and Aden. Provisions and rations allowance exhibit an increase of £248, mainly at Suakin and Perim. There is great difficulty and expense in obtaining good food for our young men at these places. A special allowance is, therefore, made to the staff at these stations. There is, on the other hand, a reduction in the following items. Travelling expenses decrease £1,355; rent, fuel, and light, £994; expenses of land lines £841, petty expenses £122.

With reference to the items shown separately in the revenue account, use of patents shows a decrease of £1,888. This important reduction is due to the expiration of Sir William Thomson's patents, to which I took occasion to refer at the last half-yearly meeting in very complimentary language as to the enormous benefit which those patents of Sir William Thomson have conferred on submarine telegraphy. I believe we could not possibly have brought submarine telegraphy up to the high position it occupies now as a great commercial power had we not had the advantage of Sir Wm. Thomson's patents. He has reaped a very fine harvest from them. The patents have now expired, and we are continuing to derive those advantages from them, and I hope they will rather increase than diminish. The next point is the depreciation of cable stores and London office furniture. Here there is an increase of £2,508. A larger stock of cable had to be depreciated this half year, and ample provision has also been made for the depreciation of London office furniture and fittings incidental to the changing of our head offices. Maintenance ships' reserve fund shows an increase of £2,000. The Directors, taking the view that the ships are tools for repairing our cables, have decided to again make a special provision to this fund. I may remind you that we were able to charge the cost of the "Volta," one of our ships, to this fund, and we hope that the revenue will continue sufficiently good to enable us to reserve about £5,000 each half-year, so that we can apply the total cost of our new ship, the "Mirror," in the same way. We shall then have added two ships to our fleet without having increased our capital account. That is what we are considering at the present time, and we give you our full confidence in telling you what we anticipate to do, though we have not definitely decided that that course will be pursued. However, our great object, as you know, is to keep down our capital, and as far as possible strengthen our system from revenue without unduly crippling our dividends. The staff endowment assurance is £1,661. This account remains about the same. The proportion of cable tanks at stations, £500. This item is the same as last time, and the same remarks apply as to the ships.

I may mention that, so anxious are your Board to make our system efficient and to be ready at all times on the shortest notice to make a repair, that we have established large tanks at our important stations in the Mediterranean and the Red Sea, where we can keep a certain stock of cable, and we have generally a ship somewhere in the neighbourhood of those tanks, so that instead of a vessel having to come to England for supplies, we are ready to ship them within a few hours near the point where the interruption has taken place. That is an enormous benefit to telegraphy and the shareholders, because the interruption of any one of our lines for any length of time, as you know, means a very large falling off in our revenue.

The expenses as to the negotiation of the Direct Spanish wires were £250. The Directors' remuneration is the same. The expenses attending repairs and renewals and laying cables amount to £45,288, against £31,189, or an increase of £14,099. It will be seen on reference to abstract "C" that full details of the work done by our ships are given. They have been constantly employed in the half-year, and in addition to the numerous important repairs effected, the "Volta" has laid a duplicate Chio-Syra cable, and completed the final sections of the Greek cables, which entitles us to a prolongation for ten years of the subsidy granted by the Hellenic Government. There is also included the charter, outfit, and the expenses of cancelling charter of the ship "Ardmellie." This vessel was chartered at a time when the relations between this country and Russia were very much strained, owing to the difficulties in Afghanistan. Had war broken out, it would have been absolutely indispensable to have our ships stationed at various points beyond Suez, in case the Canal should have been interrupted, and several of our ships would have consequently been rendered useless this side of Suez for repairs. Political affairs becoming settled, we cancelled the charter of the "Ardmellie," and decided to build a new ship, to be on hand for emergencies. For similar reasons it was decided to increase our cable tank accommodation, and this puts the Company in a very efficient position for the maintenance of our cables under any circumstances. We can, therefore, be useful to Her Majesty's Government on emergencies in the laying of cables expeditiously along our route. The shareholders will be aware that the Company has on several occasions been of special service to Her Majesty's Government, and to the commanders of our army and navy at Besika Bay, Constantinople, Alexandria, Port Said, and Suakin.

We have transferred the Sardinian cable reserves to the general fund, which now amounts to £429,178, our total reserves being £444,875. After charging all expenses, including income-tax, on our net revenue, providing for interest on debentures and debenture stock, and preference shares, we are enabled to pay a dividend, with bonus, at the rate of 6 per cent. per annum, and to carry forward £32,549, against £30,369 in the corresponding period of last year.

Now, gentlemen, I think I have given you an amount of detail which is not generally given in companies. But we have thought it desirable that, flourishing Company as we are, we should give you some opportunity of judging how we conduct the affairs entrusted to our charge; and while we manage them on a broad principle we also observe, as far as it is in our power to do so, the strictest possible economy.

There are some points referred to in the report which I am bound to allude to more particularly to-day. One of the first I have to draw your attention to is the Conference that was held at Berlin during the months of August and September last. I had the pleasure of being present with your Managing Director, Sir James Anderson, and several members of our staff. At that Conference we had a very important part to play, and the reason we had such an important part arises from the fact that these submarine companies represented at that meeting something like 100,000 miles of submerged cable, costing about £35,000,000 sterling. The whole of the submarine cables belonging to the Powers of Europe represented something like 7,300 miles, or about £1,500,000. I may say further that if you take the value of the submarine cables represented at the Conference by the different companies, it exceeds the cost of the whole of the land line system represented at that Conference. You can therefore see that the position we held was one of great importance, one that required considerable intelligence to defend; and it required a considerable amount of power and influence to impress upon the gentlemen attending that Conference how important it was for them to maintain the submarine system as far as it was in their power to do so. The submarine system benefits not only this country, for there is no country in Europe that it does not benefit to precisely the same extent, measured by the amount of commerce which they have with other nations scattered over the world. Consequently, while we have conferred this enormous boon upon the commerce of the world, and upon the countries engaged in that commerce, we have derived no special benefit from it. We are not even allowed to vote at these Conferences, and we must have a very good case or we could not maintain our position so well as we have done. At the last Conference the great object of Germany was to get something like a universal rate established for submarine telegraphy on the Continent. The German Minister of Telegraphs and Posts—a man of great power and intelligence—had been successful in establishing the universal postal system, which, I believe, has been of enormous benefit to the world at large. He thought it possible to introduce the system into telegraphy; but he found that telegraphy was a very different thing from the postal system. The consequence was that while he brought other Powers to reduce materially the rates for Continental messages, and in reducing those rates interfered considerably with our European tariff, still, after all, we found ourselves at the end of the Conference in this position. Reductions were made first to India, involving a sum of something like £27,000. The reductions which we shall be obliged to make in our European system amount to something like £13,000. Consequently, the gross amount that we may have to submit to in reductions is about £40,000. That is a large sum, gentlemen, in one sense, but it is not a large sum in another. I believe that now we see something of the dawn of better trade. We see it moving in more parts of the world than one, and there is no better evidence or a better barometer of trade than our telegraph system, and we believe that the reduced rates will contribute very largely to increased traffic, and through that increased traffic we look in a very short time to recoup ourselves for the loss which we sustain more immediately. Therefore, I do not look at that reduction in any light than that of casting your bread upon the waters, and that you will find the return after many days. Now, we had not a very great amount of encouragement in fighting our battle at Berlin. We fought it, I believe, manfully and intelligently. We had not the Press all in our favour, but the Press deliberately declared that their object was to get reduced rates, and they did not care how those rates were brought about, whether it killed us or not. Their object was to get reduced rates, and they did everything they possibly could to bring that about. I am glad to say that we were in too strong a position to be influenced by the remarks they made. But while I say that I must say one kind word for them. When war does take place abroad they are very generous and liberal to the public in providing an amount of telegraph matter which it would be impossible for other than the great newspaper power of England to pay for. Therefore, while we express a little regret at the want of sympathy of the Press on the one hand, we are bound to express our gratitude to them for the liberal support they give us when it becomes necessary for them to employ us. I may also say at the same time that I believe the Press finds in

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telegraphy a source from which to supply at any time an amount of information which would probably cost them a great deal more to pay for if such information were obtained through different channels. Therefore we stand pretty well with the Press, and in an independent position. We shall always be happy to be of use to them if we can, because we know they are of use to us when it becomes necessary for them to be so. I have given you these particulars about that Conference, and another Conference will not occur again for five years, during which we have much to do, and I hope at the end of that period we shall occupy a better position, financially and commercially, than we did before the Conference which is just ended.

The next question I have to draw your attention to, and which is referred to in the report, is the extension of our cables to the West Coast of Africa. I believe you have all read and watched with considerable attention the great interest which has been taken by Continental Powers in what was once called "the Dark Continent." Portugal has been very ambitious, and very sanguine that great returns were to come out of the West Coast of Africa. Germany has been looking at that part of the world, and has made selections there, and they are about to establish settlements. France has not been behind, either. But, after all, I believe England holds by far the most important and valuable parts on the West Coast of Africa. The Government, looking at the development of our settlements on that coast, invited tenders for a telegraphic system to connect this country with the West Coast of Africa. We have always considered it important that we should follow the English flag. Wherever the English flag floats trade is likely to be developed, and as we have been the pioneers in opening up telegraphy all over the world, we thought it would be wrong not to include in our programme the West Coast of Africa—for this reason, that we have from London our line to Lisbon. At Lisbon we join on to the Brazilian Company, which is also an English Company, and managed very much in harmony with the Eastern Company. At St. Vincent we make our departure for the West Coast of Africa. We tendered in connection with the Brazilian Company for this line which our Government desire to lay down. We obtained a concession giving £19,000 per annum. The agreement, which our Solicitor will read to you, enables us largely to control the important British traffic of the West Coast of Africa to a very great extent and without any real cost to this Company. Whatever comes from it will be a feeder to our line, and all that we are likely to invest is to take £75,000 in shares in the new Company, which we shall keep in our safe in very much the same way that we have managed our South African Company, which has been very successful, and we shall thereby obtain control over this new Company which is about to be established. We shall pay for these shares by Eastern Company's debenture stock at 4 per cent. Probably there is no greater evidence of the position and credit of the Eastern Company than the fact that it is able to issue debentures at 4 per cent. I think that is remarkable in the history of submarine cable companies. I am going to ask you to-day to pass a resolution, which will be read by our Solicitor, approving of our expending this £75,000 so as to get us very considerable control over the West Coast system. This West Coast system may eventually be extended to the Cape; but to extend it to the Cape at the present moment would be throwing away money. The British Government has realised that, and the Cape Government has also realised that. But the fact is, that if ever that is required to be extended to the Cape we shall have laid our system to such a length that a couple of months would probably enable us to extend to the Cape if so desired. I think I have laid before you to-day, as far as lies in my power, a very complete statement of your affairs in the past six months, and our reasons for going into this West African venture. I hope it will meet with your approval. With these remarks I will move:—"That the report and accounts of the Directors to the 30th September, 1885, submitted to this meeting, be, and they are hereby, received and adopted." Lord Tweeddale will second this probably, but before I ask your approval of it I shall request the Solicitor to read such points in the agreement as he considers it necessary should be in your possession.

The VICE-CHAIRMAN (the Marquis of Tweeddale): I beg to second the motion.

The SOLICITOR read the main features of the agreement.

The CHAIRMAN: You have heard the agreement, and that is included in our present resolution, and I hope you will approve of it. I will read the resolution again. [Read resolution.] If any gentleman wishes to ask any question before I put the resolution, I shall be only too happy. Then, those in favour of the motion will please hold up their hands. To the contrary. Carried unanimously. The next resolution I have to propose is:—"That Lord Sackville A. Cecil be and he is hereby re-elected a director of the Company."

Sir JAMES ANDERSON: I have much pleasure in seconding that.

The CHAIRMAN put the motion in the usual manner and it was carried.

Lord CECIL: I thank you, gentlemen.

The CHAIRMAN: The next motion is—"That Lord Alfred Paget, who now retires, be and he is hereby re-elected a director of the Company." Lord Alfred Paget has been here this morning, but, as you know, he holds an important position in the Queen's household, and he is obliged to be in attendance to-day on Her Majesty at the opening of Parliament. We are, therefore, deprived of the pleasure of his company on this occasion.

Mr. GEORGE GARDEN NICOL: I have much pleasure in seconding that resolution.

The CHAIRMAN put it in the usual manner and it was carried. Continuing he said: Mr. Price will move, and Mr. Glover will second, the resolution as to the auditors who retire.

Mr. PRICE: I beg to move—"That Mr. Henry Dever, and the firm of Messrs. Quilter, Ball, Crosbie, Glegg, and Wilton, be and they are hereby re-elected auditors of the Company for the currrent year, with a remuneration of £100 each."

Mr. GLOVER: I second that.

The motion was put to the meeting and carried unanimously.

The CHAIRMAN: Gentlemen, the next resolution is—"That the agreement submitted to this meeting dated the 19th January, 1886, and made between the Lords Commissioners of Her Majesty's Treasury of the one part and the Eastern Telegraph Company (Limited) and the Brazilian Submarine Telegraph Company (Limited) of the other part, with reference to the establishment of submarine telegraphic communication between St. Vincent (Cape de Verde) and the British possessions on the West Coast of Africa, be and is hereby approved and confirmed. That the arrangements proposed by the Board for transferring the said agreement to the African Direct Telegraph Company (Limited), and the subscription by this Company of a sum not exceeding £75,000 to the share capital of that company, and the raising of the amount required for such subscription by the issue of £4 per cent. Debenture Stock of this Company be also approved and adopted; and that the Board be authorised to do all such things as they may deem necessary or expedient in this Company's behalf to give effect to the agreement and arrangements aforesaid."

Lord TWEEDDALE (the Vice-Chairman): I beg to second that.

The CHAIRMAN: Now, if there is anyone who wishes to make any remark on the agreement I shall be very glad to listen to him. If not, I will put the motion. Those in favour of it will signify the same in the usual manner. To the contrary. Carried unanimously. Gentlemen, that concludes the business of the day.

Mr. NICHOLSON: I think, before we separate, that we may accord on this occasion a very hearty vote of thanks to our Directors for the very able way in which they have conducted the affairs of the Company during the past half year. I will not detain you longer, but I am sure I carry with me the feeling of our shareholders when I say that at the recent Conference in Germany we felt how ably our interests would be looked after by the Chairman and Sir James Anderson. This vote of thanks which I propose may be tinged with some regret, as I hear, Mr. Pender, that you have come from a sick room to attend here on such a day from a sense of the responsible position which you occupy. I would say that our Managing Director, Sir James Anderson, is so able in the admirable arrangements he makes, and in encouraging traffic, that we as merchants use the cable two or three times a week. He certainly merits our thanks for the ability and readiness with which he on all occasions makes telegraphing easy, and therefore popular. I am sure that my resolution will be readily seconded.

The resolution having been seconded, was carried unanimously.

The CHAIRMAN: I am very much obliged to you, and I thank you on behalf of my colleagues and myself. It is quite true that I have been confined to the house for the last month with a very bad cold, and this is the first public meeting I have been able to address since. I have come before you from a high sense of duty. I feel that the responsibilities which rest upon your Directors and myself in the conduct of this business are very onerous; but I feel also that the more information we can give to our shareholders the more easy is the task of conducting this large and important concern. It is a system that will bring day by day greater influence on the political and commercial system of the world. I therefore hold that this is no ordinary company. It requires no ordinary amount of attention, and it does require a very great amount of intelligence, and sometimes of courage, to carry it on as successfully as we have been fortunate in doing. Your allusion to our visit to Berlin is a just and proper one to make. Your companies were represented there with a very great deal of firmness—so much so, that we were even blamed; and we had not, as I have said, that amount of sympathy in certain quarters that we expected. But we did our duty to you and to the telegraphing public, and we shall continue to perform our duties in that high sense as long as we have the honour of being your Directors. I beg to thank you, gentlemen.

The proceedings then terminated.

Direct United States Cable Company (Limited).

The seventeenth ordinary general meeting of this Company was held at the City Terminus Hotel, Cannon-street, on the 22nd January, 1886, under the presidency of John Pender, Esq.

The SECRETARY and TRAFFIC MANAGER (Mr. J. W. Fuller) read the notice convening the meeting, and the report of the Directors and balance-sheet were taken as read.

The CHAIRMAN: Gentlemen, before making the general remarks which I usually do on these occasions, I will refer more particularly, in the first instance, to the report which you have in your hands, and which, I believe, is a very full and explicit statement of the Company's affairs. The revenue for the half year to 31st December, after deducting outpayments, amounted to £38,115, and the working and other expenses, including income tax (but exclusive of cost of repairs), absorb £16,632, leaving a balance of £21,483 as the net profit of the half year, making, with £10,734 brought from the previous half year, a total of £32,217, which has been appropriated as follows: Interim dividend of 3s. per share to 30th September, £9,106. 10s.; interim dividend of 3s. per share to 31st December, £9,106. 10s.; set aside to reserve fund, £8,037; balance carried forward, £5,967—total, £32,217. The revenue shows a reduction of £30,709 as compared with the corresponding period of 1884, owing to the reduction of tariff and competition. The working expenditure compares favourably with that in 1884. The expenses in London show a reduction of £227, while those at the stations, notwithstanding the establishment of three new joint offices at Glasgow, Bristol, and Havre, are only £129 in excess. Taking the expenditure on the whole, and including the increased income-tax item, a reduction of £226 is shown in favour of the half-year under review. The amount of £353. 15s. 5d. for expenses of ss. "Pouyer-Quertier" is a final payment, the agreement for use of this steamer

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having expired on the 8th November last, and has not been renewed. The reserve fund, with its interest, and with amount set aside from revenue, and after being debited with £3,362. 12s. for cost of repairs to cables, now amounts to £320,000. The present market value of the Company's investments is higher than the amount of their cost to the Company. Gentlemen, these are some of the details of last half-year's working, but there is one remarkable figure which I have given you, and upon which no doubt you will ask me to make some remarks. That item is the revenue, which shows a reduction of £30,709, as compared with the corresponding period of last year. That reduction arises simply from this, that instead of there being five cables in the Atlantic, which would be ample to do the work at the present moment, we have got ten. The Atlantic revenue has never at any time exceeded a million, and it has gone down instead of advancing. Every additional cable that has been laid in the Atlantic has taken away some of the traffic from the existing cables. The position that we occupy at the present time is, strictly, that we have more cables in the Atlantic than are required to do the work, and, consequently, until we get an increase of traffic or an enhanced tariff, I do not see that there is much prospect of our getting increased dividends. But in saying this I believe that common sense must eventually prevail, and that those who have lately put so much money into the Atlantic will begin to find out that they are not getting such a return for their money as they are entitled to, and that they will shortly take steps to bring about a condition of things that will be more satisfactory to them. I do not wish to discourage in the slightest degree gentlemen who may belong to other companies, but this Company occupies perhaps the best position of any submarine telegraph company in the Atlantic business. You have got, as you know, a reserve fund of £320,000 ; your affairs are managed on the most economical principle, and we have until the past year, during the nine years that we have conducted this business, paid you 5 per cent. Why, gentlemen, the reserve amounts to £5. 7s. per share, and if you take that into consideration you will see that the present value of your shares in the market does not represent really half the value of your property. Now, that is a very grand position for us to occupy ; and although the prospect at the moment is not a bright one, still we are in a good position to battle, if it is necessary to do so. Therefore, gentlemen, when I tell you that I feel disappointed with our dividend on this occasion, I am at the same time bound to say, looking at what has occurred in the way of active competition during the past twelve months, that our report is one with which we ought all to be thoroughly well satisfied. During the last eighteen months I have told you pretty well all that would happen. I am not going to refer to the different companies that have brought about this state of things in the Atlantic. I believe one extreme begets another, and that things will right themselves. But this I may say, that taking the value of all the cables in the Atlantic just now, they do not derive such a return as would justify anyone in laying down another, and consequently I believe there will be a stop put to additional competition ; and I hope, before I meet you six months hence, that such an arrangement may be arrived at as to make the tariff remunerative, and bring back a better state of things than exists at present. I dislike, above all things, what I would call throwing away money. The reduction of 4d which was made when the Mackay-Bennett cable came into the market benefited no one. It did not benefit the sender, and it has not increased the traffic. It has been an advantage to no one ; it was merely throwing £200,000 into the sea. I am loth to throw any more money into the sea. I should like to bring about an understanding without what I call "a fight." If we can do so without wasting money, it is so much more desirable and business-like, and more in accord with common sense, and I honestly believe that the men who are opposing us in the Atlantic must see, when they look at their balance-sheet at the end of the year that their investment is not yielding that return to which they are entitled. I am not going to give you their balance-sheet ; I know exactly what it will be, and I know perfectly well that they cannot be satisfied. The Western Union are in the same way. They stepped in and laid two cables, when there was no more necessity for them than there is for putting a fifth wheel upon a carriage. They are beginning to realise that they made a mistake. I hope the result of that will be that we shall come together and arrive at such a conclusion as will cause us not to throw away more money, but to bring more of it into the pockets of the shareholders. With these remarks, I beg to move:—"That the report of the Directors, dated the 13th "January, 1886, together with the statement of accounts for the half-year "ended 31st December, 1885, annexed thereto, be and the same are "hereby received and adopted."

Mr. WM. FORD: I beg to second that.

Mr. JACKSON said he had nothing to say upon the report which was not congratulatory ; but he wished to ask one question. In looking over the statement of investments on account of the reserve fund, he found that the average rate of interest earned by those investments was something like 3½ per cent. And noticing the character of the investments, he observed that there were some that were very much inferior in the estimation of the market to others that would realise a higher rate of interest. He particularly alluded to one of the most substantial securities in the City of London, which he did not see among their assets, namely, the Gas Light and Coke Company's Preference Stock, which would pay 4½ per cent. He wished now to say a few words in reference to the report. Having been long connected with this Company, he wished to signify his very great satisfaction at its present condition, and to endorse, as far as his knowledge would enable him, the remarks the Chairman had made in reference to its position among telegraph companies. No one could prevent the results of competition, as the Chairman had properly said, but a craze was a thing that must run its course, like any other disease, and would cure itself in the long run. Experience would make even fools wise, and he thought there had been a deal of folly in connection with the Atlantic cables. Therefore, he thought they might look forward, not, it was true, to anything very extraordinary in the way of returns, but to the securing of a solid and safe position. He wished to make an observation on a subject which the Chairman, in his modesty, had not adverted to. They must all recognise the great service that Mr. Pender, and the esteemed managing director of the Anglo-American Company, and Mr. Fuller, had rendered to Atlantic telegraphy in fighting their battles at the Conference at Berlin. It was a debt of gratitude that every member of the Company owed to those gentlemen. He took the opportunity, as far as he was personally concerned, of expressing his thanks to them for the labour, self-denial, and discomfort that they had undergone on behalf of all those interested in Atlantic telegraphy by attending the Conference.

Mr. W. H. CUFF wished to know whether the gross traffic for 1885 was an increase or a decrease as compared with that of 1884.

The CHAIRMAN: I am much obliged to Mr. Jackson for the kind and friendly way in which he has spoken. In the first place, I say to Mr. Jackson and to any gentleman here, that if they can make any suggestion to us in regard to any sound investment which will give us a trifle more than that which we are getting, we should only be too glad to listen to it. Probably there is no question that is more honestly or earnestly discussed at the Board than that of investing the reserve fund. We have no prejudice, but we feel, as Directors, that we ought to take no personal responsibility. We ought not to be speculative in any degree, but we ought to secure the best we can for an undeniable security. We have, as Mr. Ford reminds me, talked of such an investment, but, as you know, scares do come sometimes, and there was a very considerable gas scare two or three years ago when the electric light came to the front. I believe in electricity, gentlemen, you know. I believe the electric light must eventually become the light of the future, and without going into any detail on the subject, I may say that I never like to buy a thing when it goes up to something like two or three times the price it cost. I am saying nothing against any investment, but I like to get as near the cost price of an article as I can. What is the result of our investments? We have invested £304,921, and the value of that to-day is £5,000 more than it cost us ; so that we are that amount on the right side at a time when securities are generally rather depressed than otherwise. As I have often said at these telegraph meetings, there is no greater barometer of trade than the telegraph. It is the beginning and the end now of almost every mercantile operation, and, as Chairman of the Eastern and Eastern Extension Telegraph Companies, I can testify to this, that there is a dawn of greater prosperity in the Eastern parts of the world. There is a dawn of greater prosperity in America, and when the cycle of good times comes round—for we have passed through a cycle of bad times —you may depend upon it we shall be in a much better position. There is nothing that will benefit in a greater proportion, by the return of prosperous times, than the telegraph systems with which we are connected. So much, then, for our investments. The Berlin Conference, to which Mr. Jackson has referred, and to which probably I ought to have adverted, was a very important gathering. All the Powers of Europe, and nearly all the important Colonies, were represented at the Conference. The interest of submarine telegraphy, gentlemen, is larger than the whole of the land telegraph system of Europe. But at that Conference we had no vote ; we were allowed to speak and to bring all our facts to bear on the question under discussion, or to do what, I believe, in America they call "button hole" any of the different representatives, but we had no vote. But I must say this, that there was a desire, and a strong one on the part of the Minister of Telegraphs and Posts at Berlin, Dr. Von Stephan—a very intelligent and a very powerful man—to do what he had done, and done successfully, in connection with the postal system. He endeavoured to introduce the same system into telegraphy, but he found it would not answer. If he had carried out his point it would have made a very important difference to telegraph companies. But whether it was through our strong position or the representations that we were able to make, we held our own there, and I believe we left Berlin with the submarine cables in a better position probably than they occupied at any time before. Mr. Jackson has good-humouredly referred to my losing my parliamentary seat, but I can assure you I have lost nothing. Whenever I can serve my country with advantage I am only too glad to do so, but things have been going rather faster than I have been disposed to follow, and I am very glad that I am more at your service than I was before, as I could not have held in the House of Commons some of the extreme views that have lately been put forward. I am perfectly satisfied with things as they are. The volume of telegraphic business to America is less this year than it was the previous year, but I think that is very easily accounted for. You all know that America has been passing through a very severe commercial crisis. Some of the greatest houses have been shaken to their very foundations, and the result of this clearance, I believe, will be renewed action, renewed enterprise, and that must tell on the telegraphic system. Therefore, I look forward to increased traffic in the Atlantic, and, no doubt, we shall have our share of it.

The motion was then put to the meeting, and carried unanimously.

Mr. JACKSON then proposed a hearty vote of thanks to the Chairman.

Mr. STOCKDALE seconded the motion, Mr. GRIFFITHS remarking that Mr. Pender's ability as an administrator of telegraphic enterprise was only equalled by the urbanity of his bearing to all who come in contact with him.

The CHAIRMAN: I beg to thank you on behalf of my colleagues and myself. I can only say that we desire to be frank and explicit with our shareholders. We want you to know all that we know as far as we may speak plainly, because we feel that the more we take you into our confidence, the stronger we are to fight our battles whenever they occur.

The proceedings then terminated.

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Anglo-American Telegraph Company.

At a meeting of the Board of Directors of the Anglo-American Telegraph Company (Limited) held on the 22nd inst., it was resolved (after placing £25,000 to the credit of the renewal fund for the quarter ending 31st December, 1885) to recommend to the proprietors at the next half-yearly general meeting of the Company to be held on the 5th February next the declaration of the following dividends:—1. A balance dividend of 10s. per cent. upon the Ordinary Consolidated Stock for the year ending 31st December, 1885. 2. A balance dividend of 20s. per cent. upon the Preferred S ock for the year ending 31st December, 1885. Both payable on the 6th February next, less income-tax. After paying the foregoing dividends there will be a balance of about £4,000 to be carried forward to the next account. The above dividends, together with those already paid, will amount to £1. 5s. per cent. on the Ordinary Consolidated Stock, and £2. 10s. per cent. on the Preferred Stock for the year 1885. The company's register of transfers will be closed up to the 5th February next.

Cuba Submarine Telegraph Company (Limited).

Report and accounts of the Directors for the half-year ended 31st December last, to be presented at the twenty-ninth ordinary general meeting of shareholders to be held at the Company's offices, 61, Old Broad-street, E.C., on February 3rd next, at 1 o'clock.

From the balance sheet and accounts it will be seen that the gross receipts, including the balance brought from last account, amount to £14,966. 12s. 5d., and the gross expenditure (including the half of the annual payment on account of the 1881 cable, and the amount expended on cable repairs) to £6,325. 4s. 6d., leaving a sum of £8,641. 7s. 11d. to the credit of revenue account. The dividend on the preference shares will absorb £3,000, and leave £5,641. 7s. 11d., out of which the Directors recommend the payment of a dividend on the ordinary shares at the rate of 7 per cent. per annum, free of income tax, the balance, £41. 7s. 11d., being carried forward to the current half-year's account. The sum of £1,920. 15s. 3d. has been charged to the reserve fund, being the balance of the payment made to the contractors as per contract on the shipment and laying of the Cienfuegos-Santiago cable in 1881. The total payments in respect of this cable now amount to £21,252. 15s. 3d., all of which has been provided for out of revenue, leaving only £3,750 per annum payable for the remainder of the period, viz., to 17th February, 1893, subject to the continuous working of the cable. The fund in the hands of the Company on account of the contractors towards meeting any repairs now amounts to £4,902. 10s. 4d. The Directors have much pleasure in reporting that all the cables are in good working order. The Cienfuegos-Batabano one has, however, undergone some repairs, several faults in shallow water having been cut out by the company's engineer, Mr. Keith. These repairs, which were carried out without interruption to the working, have greatly improved the electrical condition of the cable. The British Government having invited tenders for the laying and maintaining of a cable between Halifax (Nova Scotia), Bermuda, and Jamaica, with an Imperial subsidy, the Board has fully represented to the Government that the scheme, if carried out, would prejudicially affect the interests of this Company.

The Lancashire Maxim-Weston Electric Company (Limited)—In Liquidation.

A general meeting of this Company was held on the 21st inst. at the Cannon-street Hotel, Mr. Thomas Whitworth in the chair.

The report of the liquidators having been taken as read,

The CHAIRMAN said that he had not very much to add to the report. The liquidators had touched on all points which they thought were of interest, and he reserved any remarks in case any inquiry might be made regarding anything that was not perfectly clear in the accounts. Either Mr. Brown or himself would be happy to give any information. He could only say that the undertaking, which they entered into with a light heart last March twelve months, had been a very much more arduous undertaking than they anticipated or expected. They had been met at every turn with difficulties, which, he thought, only their solicitor, Mr. Brown, and himself could appreciate. Mr. Brown had had the whole of the accounts of the Company in his hands, and was thoroughly conversant with each of the items, and if any questions were asked he would answer them.

Mr. BROWN said that he could only reiterate what Mr. Whitworth had said. They had had a very difficult task, and he congratulated them that they had arrived at the compromise they had effected. He believed that all would agree that that was a very satisfactory matter. That gave them half the capital that the y had to divide. The sale of the plant had been the principal thing. The amount paid to the parent company was about £3,400, and they realised £1,651 from the sale of the plant in the most difficult time that was ever known. Had it not been for the claim of the Maxim-Weston Company for £10,000 they would have declared a dividend of something like 14s. in the pound, but they were obliged to bow to the decision of the Court, and they had acted upon it, sanctioned and confirmed. As far as he was concerned in the matter, he should not like to undertake such another liquidation, and he was pleased that it had come to an end.

After some remarks from Mr. HAINES (the solicitor) and a shareholder as to the wisdom of the course pursued by the liquidators,

Mr. GRAY said he quite agreed that the liquidators had undertaken a most arduous duty. He moved, "That the accounts submitted to this meeting, showing the manner in which the winding-up has been conducted, and the property of the Company has been disposed of, be received and adopted."

The motion was seconded by Mr. SWABEY, and carried unanimously.

A resolution was then passed, authorising the liquidators to hand over the books of the Company to the Maxim-Weston Company.

Mr. GRAY then moved that the liquidators be requested to accept the sum of £29. 9s. 9d. appearing in the accounts, or any other balance that may be in their hands, or under their control, not exceeding in the whole £30, as an acknowledgment for the extraordinary and unexpected trouble which they have had in the liquidation, they undertaking to discharge any liability to the extent, but not beyond, the amount of the sum they so receive.

Mr. WALKER seconded the motion, which was carried, and the proceedings then terminated.

LEGAL.

The Pall Mall Electric Association.

In the Chancery Division of the High Court of Justice, on Monday, before Mr. Justice Chitty, Mr. INCE, Q C., moved *ex parte* for leave to serve copy of a petition for its winding up upon the Pall Mall Electric Association, which had its offices at 21, Holborn Viaduct, with a branch in Regent-street. The special object was that the notice should be answerable on Saturday. The Company was formed in November, 1881, and part of its business was the manufacture and sale of electric brushes, belts, and medical appliances. The capital was £16,000, in £5 shares. The petitioner, Mr. Baker, agreed with the company to hold for their benefit his "belt of life," and other trade marks, for which the Company were to pay him 5 per cent. on all sales. Balance sheets were to be drawn out regularly, but this had not been done. The Company now owed the petitioner £600. Mr. Baker had recently been in America, and on his return he learned that the company had passed a resolution to wind up. Unless, therefore, his petition could be heard on Saturday, there would be no company to wind up.

The JUDGE directed that notice of the petition should be served that day at the office of the company, and that the required advertisements should be published on the earliest possible date in the *Gazette* and two London papers.

NOTICE OF TRANSFER.—The supply department, at 11, Queen Victoria-street, London, E.C., of Messrs. Woodhouse and Rawson's electrical business, for the sale to merchants, shippers, and the trade, was transferred on the 26th inst. to a limited company, with a registered capital of £100,000.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Jan. 27.		Business Done Week Ending Jan. 27. Highest.	Lowest.
Anglo-American	32,	33	32⅜	31½
Do. Preferred	54½,	55½	56	54
Do. Deferred	9,	10	9⅜	9½
Brazilian Submarine	10⅜,	10⅞	10 13-16	10 11-16
Cuba	10¾,	11¼	11 3-16	10¾
Do. Preference	17½,	18½	18	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9,	9½	9½	9
Eastern Telegraph	11⅝,	11⅞	11⅞	11 11-16
Do. 6 per Cent. Preference	13⅝,	13⅞	13⅞	—
Do. 5 per Cent. Debentures, 1899	106,	109	—	—
Eastern Extension	12⅝,	12⅞	13	12 11-16
German Union	9½,	10½	9⅜	—
Globe Telegraph and Trust	6¾,	7	7 1-16	6 13-16
Do. Preference	13⅜,	13⅝	13¾	13½
Great Northern	14½,	15	14¾	14⅝
Indo-European	33,	34	—	—
Reuter's	7,	7½	—	—
Submarine	200,	210	208	—
West India and Panama	⅝,	⅞	—	—
Do. 1st Preference	8,	8½	8½	—
Western Brazilian	6⅜,	6⅞	7	6⅝
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telepho e and Maintenance	15-16,	1 1-16	1	—
Oriental	3-16,	5-16	¼	—
United Telephone	12,	12½	12 5-16	12

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2¾,	3¼	3¼	2 15-16
Do (fully paid)	4¾,	5¼	4⅞	4⅞
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1½,	1⅞	1 11-16	1½
Maxim-Weston	¼,	⅜	⅜	—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37	—
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24¾	23 11-16

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NOTES.

THE CANADIAN TELEGRAPHS.—Wooden telegraph poles in Canada are being replaced by iron poles.

A NEW BATTERY.—We are promised from France a new sulphate of copper cell. It is to be something wonderful.

SOUTH AMERICA.—The lines between Mexico and Vera-Cruz, and between Queretaro and San Luis Potosi are now duplexed.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 29th ult. amounted to £3,121.

RESIN.—Resin retains its insulating properties unimpaired until after the melting point is reached. It conducts when in a liquid state. This applies to all the resins.

GENEROUS.—We are informed that Mr. J. W. Mackay has presented the whole of the *employés* of the Commercial Cable Company with a bonus of half a month's pay.

THE POSTMASTER-GENERALSHIP.—At the time of our going to press no definite appointment had been made to the Postmaster-Generalship under the new Government.

THE ERUPTION OF COLIMA.—A Reuter's telegram, dated New York, January 31, says a telegram from Mexico states that the Colima volcano continues in active eruption.

A SNOW STORM.—A snow storm, with a gale, which is described as of cyclonic fury, passed over the Peterborough district on Sunday afternoon, doing much damage to telegraph wires.

BALATA AS AN INSULATOR.—Balata, which is obtained from the bark of the bullet tree (*Mimusops balata*), of Guiana, is said to possess electrical insulating properties quite equal to those of gutta percha.

A LONG TRANCE.—It is stated from Nebraska that a young woman resident there was awakened by a shock from a galvanic battery, after having remained in a cataleptic trance for seventy days.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of January amounted to £1,686, against £1,756 in the corresponding period of last year.

UTILISING NIAGARA.—The Niagara Falls and Whirpool Railway Company has been incorporated, with $100,000 capital. As yet it has not been decided whether steam, water, or electricity will be used.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELGRAPH COMPANY.—The traffic receipts of this company for the month of January, amounted to £39,699, and to £44,144 in the corresponding period of 1885.

THE BENEVOLENT ASPECT OF EARTHQUAKES.—Mr. Proctor is of opinion that, paradoxical as it may sound, the earthquake is a regenerative and restorative agent. To quote an Americanism, "We don't want any in ours, thank you !"

LIGHTING VEHICLES.—It is said that the King of Bavaria has some fine sledges, in which he frequently travels by night. He very much wished to have them electrically lighted, but, unfortunately, no room was available for the accumulators.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 29th ult. were £2,438, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

EARTHQUAKE IN SPAIN.—A Reuter's telegram, dated Madrid, January 30th, says :—"Yesterday afternoon a strong shock of earthquake was felt at Velez Malaga. No details have yet been received, but the town is reported to have suffered little damage."

ANOTHER UNDERGROUND SYSTEM.—A new underground wire system, originated in New York, contemplates the construction of two arched subways, so that wires carrying strong currents shall not inter-act upon those designed for the telegraph and telephone.

THE ELECTRIC LIGHT IN FRANCE.—La Gare de l'Est, at Paris, is now electrically lighted by Cance arc lamps. The substitution of the new luminant for gas is already much appreciated, and we hope to hear shortly of some extensions being made in this direction.

NOTICE OF MEETING.—The usual half-yearly ordinary general meeting of the Anglo-American Telegraph Company will be held this day (Friday) at the Cannon-street Hotel, at two o'clock precisely. A full report of the meeting will appear in our issue of the 12th inst.

THE TELEPHONE COMPANY OF AUSTRIA.—The accounts of this company, from the date of incorporation to June 30 last, show a credit balance to revenue of £432, which the directors propose to carry forward. The accounts are in future to be made up annually to March 31.

MAXIM-WESTON.—It is announced that the directors of the Maxim-Weston Electric Company have decided to pass a sum of £3,600 to a general reserve account, and to recommend a dividend of 7½ per cent. for the past year, carrying forward a balance of about £600 to next year.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended 31st ult. are £2,799, as compared with £2,766 in the corresponding period of 1885. The October receipts estimated at £3,894 realised £3,940.

FRANCE AND TONQUIN.—Since Friday night last France has been in communication with Tonquin without military supervision, an independent telegraph office having been established at Lang-Son, through which not only official but commercial messages pass in the ordinary way.

ELECTRIC ROAD ROLLERS.—Mr. E. Gellerat's electric road roller is again exciting attention. As will be remembered it is driven by two dynamos and steered by another dynamo. About 100 accumulators are used, and the gross weight of the machine is 18 tons. About 13 horse-power is developed altogether.

ITALY AND THE RED SEA.—It is reported from Rome that the Italian Minister of Public Works is about to lay a proposal before the Government for the establishment of a submarine telegraph cable between Massowah and Assab Bay in connection with the system of the Eastern Telegraph Company.

THE ELECTRIC LIGHT AND SCIENTIFIC RESEARCH.—A new apparatus for the application of the electric light to microphotography has been designed by M. Yvon. An incandescent lamp supplied with current by a six-cell Trouvé battery is used. The advantage is that the light is uniform and steady.

THE BRITISH ELECTRIC LIGHT COMPANY.—In the Chancery Division of the High Court of Justice, on Friday last, Mr. Justice Chitty heard an application by debenture-holders in this company for the appointment of a receiver. The learned judge granted the application, and appointed the secretary of the company as receiver.

PROPOSED LIGHTING OF A BOROUGH.—At their last monthly meeting the Hanley Town Council passed a resolution,

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on the recommendation of the General Purposes Committee, appointing a sub-committee to consider the desirableness and the cost of lighting the public buildings, and eventually the public streets of the borough, by electricity.

RESISTANCE AT LOW TEMPERATURES.—From some experiments carried out by M. Wroblewski, it would appear that the variation in the resistance of copper is proportionate up to a very low temperature. In every case the coefficient only varied ·0004 between + 21°C. and − 193°C., but at − 200°C. it became ·00197 higher in one case, and ·002819 in another.

THE CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of January was 3,485, estimated to produce £2,850, against 3,555 messages, producing £3,013, in the corresponding month of last year. The traffic receipts for the month of October, estimated at £2,100, realised £2,156.

OVERHEAD WIRES.—Sir Henry Tyler has given notice of his intention to ask the Home Department for a return of the failures of telegraph and telephone wires, used overhead in the metropolis, during the recent snowstorm, and of the accidents thereby caused. The question thus raised is an important one, both as affecting the public and the telephone companies.

ST. JAMES'S VESTRY AND THE ELECTRIC LIGHT.—At the last meeting of the St. James's (Westminster) Vestry, the Lighting Committee recommended that the Board of Trade be requested to oppose the Bill of the West London Electric Lighting Company, and that the vestry do oppose the draft provisional order as a whole. The recommendation was adopted.

ROYAL INSTITUTION.—At the general monthly meeting of the members, held on Wednesday, Mr. Warren de la Rue, D.C.L., F.R.S., vice-president, in the chair, Messrs. Wm. Anderson, C.E., H. A. Blyth, J. Blyth, J. Crowdy, Brownlow D. Knox, and W. F. R. Weldon, M.A., and Mrs. Shepherd were elected members, and 16 candidates for membership were proposed for election.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—A meeting of this society will be held at the Institution of Civil Engineers, 25, Great George-street, on Thursday, 11th February, 1886, when a discussion will take place upon the paper, "Self-Induction of an Electric Current in Relation to the Nature and Form of its Conductor," by Prof. D. E. Hughes, F.R.S, President.

CITY GUILDS TECHNICAL COLLEGE: OLD STUDENTS' ASSOCIATION.—The first ordinary general meeting of this recently-formed association was held at the Finsbury Technical College, on the 2nd inst. A paper was read by Mr. E. Smart upon the Swanikoff arc lamp, for which he claimed simplicity of construction and steadiness of action. A discussion followed in which Mr. Walmsley and others took part.

THE TELEPHONE IN EDINBURGH.—At the last meeting of the Edinburgh Town Council it was agreed to accept the estimates of the National Telephone Company for wire from the Exchange to the City Hospital at £15 per annum, and for wire to the City Chambers at £10 per annum, and the estimate of Alexander Maclean and Co. for wire from the City Hospital to the office of the medical officer of health at £5 per annum.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY (LIMITED).—The accounts of this company for the past year show an available sum of £158,326, including £40,070 brought forward and £52,394 premium on new shares issued during the year. A dividend of 15 per cent. is proposed, of which 5 per cent. was paid in July. The sum of £55,000 is to be added to reserve, leaving £40,947 to be carried forward.

THE ELECTRIC LIGHTING ACT.—At a general meeting of the Electric Lighting Act Committee, recently held at the offices of the Anglo-American Brush Electric Light Corporation, Belvedere-road, Lord Thurlow in the chair, a resolution was adopted, on the motion of Viscount Anson, approving the action of the executive, and expressing satisfaction at the announcement that Lord Rayleigh had, at the request of the executive, agreed to introduce the Bill drafted by the committee into the House of Lords.

THE NATIONAL TELEPHONE COMPANY.—At a meeting of the directors of this company, held on Wednesday last, it was resolved to declare an interim dividend for the six months ending 31st December last at the rate of 6 per cent. per annum on the First and Second Preference shares, and at the rate of 3 per cent. (as against 2 per cent. for the corresponding period last year) on the Ordinary shares, and that the balance of £2,685. 5s. 2d. should be carried forward. The unaccrued revenue carried forward to the credit of next account amounts to £34,058. 18s. 10d., as against £29,995. 16s. 5d. last year.

TO INDICATE FIRE DAMP.—An apparatus has been invented by a Mr. Carleton, of New York, for the purpose of indicating fire damp in coal mines. It consists briefly of two mercury bulbs, the ends of which are inserted into helices of fine wire. The two bulbs are equal in bulk, and the two helices of the same resistance. One bulb is placed in a pure atmosphere of any required temperature, and the other in a current of air flowing from or in the mine. The difference in resistance between the two bulbs is then, from time to time, measured electrically, and the amount of fire damp ascertained.

MANILA ROPE.—As Manila rope enters very largely into deep-sea grappling, the following may interest some of our readers:—To detect the presence of adulterations, such as sisal fibre, in presumably pure Manila rope, untwist a small piece, and prepare the yarn by carefully separating the fibres, roll into a ball in the palm of the hand, and then burn out on an iron shovel. Pure Manila hemp will give a dull, grayish black ash; sisal hemp will give a whitish grey; and sisal and Manila mixture a grizzly white and black ash. The different fibres are distinctly visible.

BATTERY SOLUTIONS.—M. Damian has found that a zinc, copper, sulphate of magnesia cell gives excellent results. The E.M.F. varied only 0·02 volt during ten months, its maximum being 1·06 volt. The solution continues clear, and the surface of the metals clean. The E.M.F. is not affected by the degree of concentration of solution, and temperatures between 6° and 35° C produce no appreciable effect. For a cell of amalgamated zinc, platinum, and dilute sulphuric he found the best results when the solution contained 30 to 100 of acid, and was at a density of 1·223. The E.M.F. was then 1·345 volts at 15° C.

COMMUNICATION WITH CANADA.—At a recent meeting of the Montreal branch of the Imperial Federation League, the following resolution was passed:—"That this meeting is, therefore, strongly of opinion that a petition should be presented by the Imperial Federation League to the Dominion Government, praying it to take such steps as it may deem best fitted, by money grant and otherwise, to encourage the formation of an organisation by the Canadian Press, independent of party, for the purpose of securing a daily telegraphic interchange of news with the mother country, which shall be free of all influence external to the Empire.

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ANNUAL DINNER.—A few nights ago the *employés* at the Arc Electric Light Works, Chelmsford, had their annual dinner at the Corn Exchange. Provision was made for 289 guests. During the course of the evening Mr. R. Britton, in a happy little speech, gave "The firms of Messrs. R. E. Crompton and Co. and Messrs. Crompton and Fawkes." He stated that at the first dinner he attended in connection with the firm 29 men were present, and at the second there were something like 43. He also spoke of the time when only one man was employed in Chelmsford in connection with the electric light industry. Mr. Britton then referred in complimentary terms to the heads of the two firms.

INFLAMMABILITY OF COAL DUST.—According to some recent experiments carried out in the Königs Mine at Neunkirchen, in Germany, the flame from a blast hole filled with coal dust attains to a length of from 26ft. to 164ft., according to the quality of the coal. Ignition was effected by electricity. The use of electricity and the electric light is referred to by the *Eisen Zeitung* in connection with these experiments, recent investigations having proved that electricity separates dust, smoke, gas, &c., from the air, and deposits them upon the walls of a vessel, tunnel, or shaft. By the use of hermetically closed lamps it is possible, moreover, to keep electric light from contact with gases in mines.

BRUSSELS.—M. Léon Somzee is urging upon the Belgian Government the necessity of taking measures to obviate the dangers resulting from the use of overhead telephone and telegraph wires in towns. He also recommends the appointment of a special commission to examine into and determine the tensions which, presumably in electric light leads, may be employed with absolute safety to life. M. Alph. Nothomb demands that this commission shall also study the question of the dangers to life and property resultant upon the usage of gas. This is but fair, for there are certainly two sides to this question. It will be remembered that M. Somzee is practically the representative of the gas interest in Belgium.

SOCIETY OF ENGINEERS.—The first meeting for the present year of the Society of Engineers was held on Monday evening at the Westminster Town Hall. The President for 1886, Mr. Perry Fairfax Nursey, in his inaugural address, speaking of the present advanced state of engineering science and practice, observed that the people were rather prone in the present to exalt themselves at the expense of the ancients, although the latter had manifested in many instances a large amount of scientific skill and knowledge. As an instance of this fact, it was true that the electric telegraph was defined by Galileo in his "Systema Cosmicum" two centuries and a half ago; while the lightning conductor of Franklin was used by the Etruscans.

RIVAL CODE BOOKS.—In the Chancery Division on Wednesday last, the case came on for hearing in which Dr. George Ager, the compiler of "The Standard Telegraph Code," a book sold for £5. 5s. a copy, proceeded against Messrs. Collingridge for printing what was alleged to be a pirated edition of the work for Messrs. Shadbolt, the compilers of what was called "Shadbolt's Telegraph Code," adapted specially for the timber trade. The defence was that the plaintiff's book was not a proper subject for copyright, and that they had never had any intention of using their version of it except for themselves and their correspondents. Mr. Justice Kay held that the book was copyright; but as the defendants were going to appeal he pronounced no decision on the question of damages.

THE ELECTRIC LIGHT FOR WARSHIPS.—Orders have been received at Sheerness directing the "Caroline," 12, unarmoured screw corvette, 1,620 tons, 1,012 horse-power, Captain Sir William Wiseman, to be fitted with the electric search-light before her departure for the Pacific Station to relieve the "Satellite." The Admiralty some time ago ordered the "Alacrity," despatch vessel, to be instantly prepared to temporarily relieve the "Helicon" as tender to the flagship in the Mediterranean, without waiting to receive her armament, steam steering gear, or electric lighting. They subsequently countermanded the order, instructing the dockyard authorities at Portsmouth to prepare her for her guns, and to complete her equipment for a regular commission at sea.

FUNERAL OF A TELEGRAPH MESSENGER INSPECTOR.—On the 28th ultimo, at Highgate Cemetery, the remains of the late Inspector George Rose, of the Central Telegraph Office, General Post Office, were interred in the presence of a large gathering of friends and brother officers of the deceased. A detachment of fifty messengers from the Central Telegraph Office, under Chief Inspectors Howard and Austin, assisted by Inspectors Reid, Brown, Doran, Parsons, and Cromarty, paraded outside the cemetery gates at 3 p.m. to pay a last tribute of respect to the deceased officer, and followed in procession to the grave. A handsome wreath of natural flowers presented by the inspectors, tube attendants, and messengers of the Central Office was placed upon the coffin, together with others, sent by the deceased's friends.

SCIENCE AND POPULAR GOVERNMENT.—Discussing this matter in the present month's *Nineteenth Century*, especially as illustrated by the American democracy, Mr. E. L. Godkin, says: "The kind of fame which came to Edison after he had made some improvements in the electric light and invented the phonograph, was a very good illustration of the respect of American people for the novel and the marvellous. For a good while he was hailed as a man to whom any problem in physics would be simple, and he was consulted on a variety of subjects to which he had given no attention, such as the means of diminishing the noise of the trains on the elevated railroads in the streets of this city [New York]. In fact, for a year or two, he held the position—doubtless to his own amusement—of a 'medicine man,' to whom any mystery was easy."

BALLOONING.—In Captain Renard's experiments, which took place on the 22nd of August, and the 22nd and 23rd of September last year, the motor employed was a Gramme dynamo electric machine making 3,000 revolutions a minute, and developing 9 horse-power. The current actuating the machine was furnished by a battery. On the 22nd of September the speed of the wind was from 3 metres to 3·50 metres per second. The balloon left Chalais, carrying three persons, at 4:25 p.m., the sky being cloudy. It was steered against the wind, and at 5 p.m. arrived over the Ile de Billancourt with a speed of 6 metres per second, the Paris fortifications being reached at 5:12 p.m. The return journey was accomplished in 11 minutes, while the outward journey had occupied 47 minutes. The maximum height attained was 400 metres.

EDINBURGH TELEGRAPH MESSENGERS.—On the 27th ultimo the fifteenth annual entertainment to the Edinburgh telegraph messengers was given in the Waverley Hall. Mr. Andrew Gray, superintendent, who presided, said that since their last meeting there had been a considerable change in regard to matters telegraphic by the introduction of a lower rate for telegrams. This change had increased the difficulties and labours of the boys considerably, owing to people sending messages addressed, for instance, "John Smith, Grassmarket," no number being given. This was probably want of thought sometimes; but some people had no scruple in asking the boy to take a great deal of trouble for the penny that he received

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so that they might save one themselves. The object of the telegram was to effect speedy communication; and those who were so pennywise sometimes defeated their object.

ANIMAL ELECTRICITY.—Another very remarkable cure is said to have been effected at Whitstable by means of animal electricity. A nephew of Captain Foster, of Victoria-street, was suffering from St. Vitus's dance in its worst form. Previous to Christmas he could neither hold his head nor a limb still, nor even dress himself; but two or three weeks ago the case was brought under the notice of Mr. Barham, a member of the Anthropological Institute of Great Britain and Ireland, a gentleman who has given careful attention to the science of animal electricity, and is an ardent believer in it. Mr. Barham's method of treatment was immediately successful, and the patient, a boy of about fifteen years of age, is now restored to health. He can dress and undress himself, and has not the slightest symptoms of twitching. The operator, it is said, has been equally fortunate in the treatment of paralysis.

NEW FORMS OF THERMOPILES.—In this paper, by H. Kayser, measurements are given of the electromotive force and resistances of various forms of thermopile, the source of heat being a gas flame burning a known number of litres of gas per hour. The electromotive force of a Noë-Rebiceck's thermo-electric pile of 20 elements was found to be constant for an indefinite length of time, provided that the external conditions, namely, gas pressure and temperature of the air, were unaltered; its electromotive force also exceeded that of a Bunsen element. The internal resistance increased to a maximum, with a consumption of gas from 0—60 litres per hour, and from that point to 110 litres per hour it diminished; the maximum resistance of a pile of 25 elements was 0·868 ohm. The relative advantages of a thermopile over a Bunsen element in cases of small external resistance are also discussed.—*Jour. Chem. Soc.*

PIGEONS AS MESSENGERS IN WAR.—Lecturing on this subject, on Friday last, at the United Service Institution, Captain H. T. W. Allatt pointed out that our telegraphic communications with the external world might be severed without an invasion. Our submarine cables might be cut by an enemy who had never come within sight of our island, and it would obviously be difficult to watch and protect them all. In such an emergency pigeons would afford a means of maintaining direct, cheap, and speedy communication with the Continent. A further use of the birds applicable to our insular position would be found in their employment as messengers from an observation ship or fast cruiser told off to watch an enemy's fleet. By having a suitable number on board every movement of the enemy could in moderate weather be reported in the day-time to a military station on shore.—A discussion followed, in which the chairman (Sir Beauchamp Walker), Major-General Hassard, and others took part.

DOMESTIC LIGHTING.—Last week on the occasion of a ball given by Sir A. B. Walker, Bart., at Osmaston Manor, near Ashbourne, the mansion and ball room were lighted by the electric light, some 200 sixteen candle-power incandescent lamps being used for this purpose. Sir Andrew Walker having decided to light the house placed the order for carrying out the work in the hands of the Liverpool Electric Supply Company early in January, and by the 29th ult. a twenty horse-power compound engine of Messrs. Marshall and Sons' make had been fixed in position and was driving a dynamo capable of supplying 400 lamps, to which extent it is intended to increase the lighting. The work of building the engine shed and erecting the plant was carried out under considerable difficulties owing to the short time available. The fittings for the house have all been carefully designed with a view to their adaptability to the different rooms. The whole of the work was superintended by Messrs. Holmes and Vaudrey.

REGULATING THE TEMPERATURE.—Another device for automatically maintaining an even temperature in enclosed places by means of electricity was recently shown at the American Institute Fair. The apparatus consists of a wooden frame, which may be placed either in the upper or lower sash, divided into alternate parts of glass and metal. The metal strips are pivoted at each end and all attached to one metal bar, which is connected at one end of the frame with the armature of an electro-magnet, covered by a wooden box, and the other end is drawn back by a spiral spring. The thermometer has a wire let into the bulb, and also one fused into the glass tube at any desired degree. The electro-magnet, thermometer, and battery are connected by insulated wires. The mercury in the tube, acting as part of the conducting wire, as it rises and falls, connects, and disconnects, with the wire fused in the side of the tube, thus alternately attracting and releasing the armature, and thereby opening and closing the movable slats in the frame.

ANOTHER MINER'S LAMP.—At the recent conference of the Miners' Union, Mr. Burt, M.P., the president, observed that a very desirable thing was the provision of a good useful light. An electric lamp for the miners' personal use was an admirable thing. They had one before them, which was self-contained, and consisted of a battery composed of three cells, each 6in. high by 3in. wide and 1in. deep. Each cell consisted of a charge of chloride of silver and two thin zinc plates, a weak solution of caustic potash being added. The current produced supplied a small glow lamp, of German manufacture, placed in front of the metallic case containing the battery after the fashion of the bull's-eye of a police lantern. The light by this lamp was stated to be of 3 candle-power, and to be capable of burning for nine hours; but this, as far as candle-power g oes, is in excess of the requirement of the miner, so that smaller sizes are made. One of these is circular in form, 3i n. in diameter, 3in. deep, and of 2 candle-power, and will burn for five hours.

THE INDIAN TELEGRAPH SERVICE.—*The Times* Calcutta correspondent writes:—Saturday's official *Gazette* contains the annual administration report of the Indian Telegraph Department, and a highly appreciative Government resolution thereon. The year under review was marked by a great development of the telegraphic service. The number of Government signal offices was increased 50 per cent., and the total number of offices, including those of the railways, is now 2,035. The length of the lines was increased by 2,046 miles to 25,387 miles, and the length of the wires by 6,279 miles to 75,115 miles. The Burmah-Siam line has been successfully completed, and a new cable has been laid to Ceylon. The surplus revenue was Rs.11,67,918, being 3·3 per cent. on the capital expenditure. The revenue was the largest yet earned, the number of complaints diminished, the speed of transmission was improved, the interruptions were decreased in number, and the arrangements for utilising the agency of the Post Office made progress during the year.

COMMUNICATION AT SEA.—Prof. Bell says:—"Most of the passenger steamships are equipped with electrical plant. Suppose one of them should trail a wire of any length, which is connected with the dynamo engine and electrically charged. The wire would have an earth connection by trailing in the water. Suppose a telephone was then attached to the end on board. Then the dynamo or telephone end would be positive, and the other end of the wire in the water would be negative.

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All of the water about the ship would be positive within a circle whose radius is one-half of the length of the wire. All of the water about the trailing end of the wire will be negative within a circle whose radius is the other half of the wire. If the wire is one mile long, there is then a large area of water about the ship which is affected either positively or negatively by the dynamo engine and the electrically charged wire. It will be impossible for any ship or object to approach within the water so charged in relation to the ship, without the telephone telling the whole story to the listening ear. Now, if a ship coming in this area also has a similar apparatus, the two vessels can communicate with each other by their telephones. If they are enveloped in a fog, they can keep out of each other's way. The ship having the telephone can detect other ships in its track, and keep out of the way in a fog or a storm. The matter is so simple that I hope our ocean steamships will experiment with it. The principle is not new; it is old, with a new use waiting for commerce to utilise it." This looks very nice, but even if the wire so trailed were, say, a mile in length, there would only be a working radius of half a mile. Close quarters; to say nothing of the inconvenience of trailing a mile of line.

Some Considerations Regarding Induction.—In the current issue of our American namesake appears a very interesting article by Mr. David Brooks upon the phenomena of induction in relation to the working of telegraph and telephone lines. After declaring that induction is not a myth, the writer goes on to say that it can only be produced, or at least developed to its greatest extent, by very high insulation, whether upon parallel conductors or in induction coils. The inductive effects are lessened as neighbouring conductors are multiplied, and are more pronounced upon overhead telephone wires in clear cold weather than when rain prevails. The law of inductive effect between wires is laid down by present writers as being inversely in proportion to the distance by which they are separated by insulation. Take, however, 100 telephone wires strung upon a line of poles so that the 100 conductors occupy a sectional space of 100 square feet. If these wires extend one mile, and are used exclusively for telephone purposes, very marked inductive effects are observable. In the telephone cable the wires are 14,400 times nearer to each other, and the inductive effects should be 14,400 times greater, but they are not. It is probably more a matter of acoustics. Cotton, or other textile material, saturated with paraffin, has much less electrostatic capacity than paraffin itself, and cotton-covered wire, when saturated with oil, has a much less electrostatic capacity than when saturated with solid paraffin. The more compact the cotton covering, and the less oil or paraffin absorbed by it, the less the electrostatic capacity. Moderately low insulation is the best condition for automatic telegraphing or telephonic operations, say one megohm per mile. Retardation is the result of too high insulation. In such case the use of artificial leaks is advised.

The Lighting of Askam.—At the last meeting of the Dalton Local Board the Electric Lighting Committee reported as follows:—"In continuation of their report, submitted to the Board in November last, the committee have to state that, having considered the report of the engineers (Messrs. Badger and Sons, of Rotherham), upon the condition of the engine and boiler originally proposed in his specification to be furnished by Mr. Menzies for electric lighting purposes, which the engineers found in many respects defective, and to require considerable repairs, the committee could not accept the same. The above recommendation is made to the Board for adoption, subject to the Local Government Board's approval of the electrical lighting scheme. That the former resolutions of the Board in reference to the application for loan be varied as follows:—That application be now made to the Local Government Board for sanction to borrow the sum of £1,600 for electric lighting purposes, the repayment whereof shall extend over a period of 20 years." Mr. Hammond moved the adoption of the report. He said Prof. Jamieson's report showed that the place was well adapted for the light; it also suggested that they should have an additional dynamo, in case of accident. The Board would get 120 lamps, with double the illuminating power, at the same price that they were paying for 60 lamps. They could with the proposed plant extend the number of lamps to 240 without extra man or labour. The total cost, including engine house, &c., would be £1,542. It had been thought wise to have a report as to the second-hand engine, and it had been unfavourably reported upon, and tenders were obtained for another engine and boiler. They proposed to apply for power to borrow £1,600, although he did not think the whole of this sum would be expended. At the same time the committee thought it advisable to apply for £1,600. The report was adopted.

Electrical Tramways.—Mr. Gooch has summarised the comparative values of cable and electric tramways, in the *Yorkshire Post*, as follows:—"(1) Excessive first cost of construction. (2) That if the cable is broken the whole of the traffic in both directions is suspended until repaired. (3) Should one of the cars be delayed, it practically impedes during the journey the whole of the others, as it cannot recover the time lost by going faster than the rate the cable nominally travels. (4) The cable runs on pulleys at short intervals; consequently you have a very large number of moving parts, which require lubrication and adjustment, and are apt to cause great inconvenience and delays, to say nothing of cost in money and labour. (5) On an extensive system the weight of the cable and consequent friction absorbs a large portion of the power unproductively. (6) Sharp turnings, crossing places, and sidings, &c., can only be worked with great difficulty. (7) There is no possibility of backing a car to avoid collision, or for other necessary purposes. This is a sufficiently formidable summary of objections to the cable system, and, at the same time, does not give all." Turning to electricity, and using only storage batteries for the motive power, as used at Berlin and Antwerp, the cars thus driven: (1) "Have few but reliable mechanical working parts. (2) Are independently driven, any car being able to make up time in case of delay by going faster. (3) There is no noise such as is inseparable with the running of cables over pulleys in the centre of the street. (4) No other permanent way is required beyond the ordinary tram rails. (5) Electric traction by storage will be found more reliable and more economical than traction by the cable system. (6) The electrical system is capable of any expansion by placing an increased number of cars in service, whereas the cable system is necessarily restricted to a certain amount of work in accordance with the original strength of parts and power supplied. (7) The deterioration, if any, of the transmitting power is localised to each cor, and is not general as in the case of the deterioration of a cable on which the haulage of many cars depends. (8) The sidings, turnouts, sharp curves, and other ordinary difficulties of the road are perfectly dealt with by the storage system. The same favourable remarks apply to electrical systems in which the transmission of power to the car from a central station is arranged for."

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ELECTRICAL THEORIES.*

BY PROF. J. J. THOMSON, M.A., F.R.S.

In this report I have confined myself exclusively to the consideration of those theories of electrical action which only profess to give mathematical expressions for the forces exerted by a system of currents, and which make no attempt to give any physical explanation of these forces. For it is evident that, before we can test any theory of electrical action, we must know what the actions are which it has to explain, and we cannot do this until we have a satisfactory mathematical theory. I have further limited myself to the consideration of the fundamental assumptions of each theory, and have not attempted to give any account of its mathematical developments, except in so far as they lead to results capable of distinguishing between the various theories.

I have divided the theories into the following classes:—

1. Theories in which the action between elements of current is deduced by geometrical considerations, combined with assumptions which are not explicitly, at any rate, founded on the principle of the "Conservation of Energy." This class includes the theories of Ampère, Grassmann, Stefan, and Korteneg.

2. Theories which explain the action of currents by assuming that the forces between electrified bodies depend upon the velocities and accelerations of the bodies. This class includes the theories of Gauss, Weber, Riemann, and Clausius.

3. Theories which are based upon dynamical considerations, but which neglect the action of the dielectric. This class contains F. E. Neumann's potential theory and Von Helmholtz's extension of it.

4. C. Neumann's theory.

5. Theories which are based upon dynamical considerations, and which take into account the action of the dielectric. This class includes the theories of Maxwell and v. Helmholtz.

We shall now proceed to the detailed consideration of these theories.

The best known theory of this class is that of Ampère; others, however, have been given by Grassmann, Stefan, and Korteweg, which we shall consider in order.

Ampère's Theory.

This theory was first published in 1820. In 1823 appeared his great paper the "Memoire sur la theorie Mathematique des phénomenes Electrodynamiques," "Memoirs de Institut," t. 6, which Maxwell describes as "perfect in form and unassailable in accuracy," and which at once brought the action between electric currents under the power of mathematics. Ampère founded his theory on certain postulates which he attempted to establish by experiment; inasmuch, however, as he always dealt with closed circuits in his experiments and elements of circuit in his postulates, the experimental evidence is not quite satisfactory. Ampère's experiments have been repeated by Von Ettingshausen,† with much more delicate apparatus.

The postulates used by Ampère are as follows; the first four are given in the words of Prof. Tait [Tait's "Quaternions," 2nd Ed., p. 279]:—

I. Equal and opposite currents in the same conductor produce equal and opposite effects on other conductors, whence it follows that an element of one current has no effect on an element of another which lies in the plane bisecting the former at right angles.

II. The effect of a conductor bent or twisted in any manner is equivalent to that of a straight one, provided that the two are traversed by equal currents and the former nearly coincides with the latter.

III. No closed circuit can set in motion an element of a circular conductor about an axis through the centre of the circle and perpendicular to its plane.

IV. In similar systems traversed by equal currents the forces are equal.

V. The action between two elements of current is a *force* along the straight line joining them, and proportional to the product of the lengths of the elements and the currents flowing through them.

It follows from IV. that the force between two elements of current varies inversely as the square of the distance between them. The assumption V. is one that can only be satisfied by the correctness of the results to which it leads. We have no right to assume *a priori* that the action is equivalent to a single force and not to a force and a couple, and we have no more right to assume that the force is along the line joining the elements than we have to assume that the force between two small magnets is along the line joining their centres, and in this case the assumption is untrue. It is in the nature of the assumption V. that Ampère's theory differs from others of this class. The second part of I. depends upon V. It is not true unless we assume that the force between the two elements is along the line joining them.

Ampère deduces the force between two elements of current from these principles as follows:—Suppose we have two elements of current of lengths ds_1, ds_2, traversed by currents of strengths $i\ j$ respectively; let us take the line joining the centres of these currents as the axis of x; let the plane of ds_1 and x be taken as the plane of xy; let $\theta_1\ \theta_2$ be the angles which $ds_1\ ds_2$ respectively make with the axis of x, η the angle which the plane through ds_2 and r makes with the plane of xy.

By Ampère's second proposition the action of ds_1 on ds_2 will be the sum of the action of

$$\begin{cases} ds_1 \cos\theta_1 \text{ or } \alpha_1 \text{ along } x \\ ds_1 \sin\theta_1 \text{ or } \beta_1 \text{ along } y \end{cases}$$

on

$$\begin{cases} ds_2 \cos\theta_2 \text{ or } \alpha_2 \text{ along } x \\ ds_2 \sin\theta_2 \cos\eta \text{ or } \beta_2 \text{ along } y \\ ds_2 \sin\theta_2 \sin\eta \text{ or } \gamma_2 \text{ along } z \end{cases}$$

Now, by proposition (1) α_1 cannot exert a force on either β_2 or γ_2, because it is in planes which bisect β_2 and γ_2 at right angles, so that the only component on which α_1 can exert a force is α_2. Let the force between these components be

$$\frac{a}{r_2}\alpha_1\,\alpha_2.$$

where r is the distance between the centres of the elementary currents.

In the same way we can show that the only component on which β_1 can exert any force is β_2. Let the force between these two elements be

$$\frac{b}{r_2}\beta_1\,\beta_2$$

Thus the force between the two elements $ds_1\ ds_2$ is

$$\frac{1}{r^2}\left\{ a\,\alpha_1\,\alpha_2 + b\,\beta_1\,\beta_2 \right\}$$

or substituting for $\alpha_1\ \alpha_2\ \beta_1\ \beta_2$ their values

$$\frac{1}{r^2}\left\{ a\cos\theta_1\cos\theta_2 + b\sin\theta_1\sin\theta_2\cos\eta \right\} i\,j\,ds_1\,ds_2$$

The proposition (III.) that the action of a closed circuit on an element of current is always at right angles to the element leads on integration to the condition

$$2a + b = 0,$$

so that the force between the two elements equals

$$\frac{a}{r^2}\left\{ \cos\theta_1\cos\theta_2 - 2\sin\theta_1\sin\theta_2\cos\eta \right\} i\,j\,ds_1\,ds_2.$$

From this we are able to find the force between any two circuits or parts of circuits. To find the force on a magnetic system Ampère used his principle that the magnetic action of an electric current was the same as that due to a magnetic shell bounded by the circuit and magnetised to the proper intensity. In this way Ampère gave a complete theory of the action of currents upon currents and upon magnets—in fact, a complete theory of all the effects produced by a current which were known when his paper was published.

* Report presented to the British Association Meeting at Aberdeen, September, 1885.

† "Ueber Ampère's Electrodynamische Fundamentalversuche," &c. Wien Ber. (11), 77, p. 109, 1878.

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It is difficult to overrate the service which Ampere's theory has rendered to the science of electrodynamics. Perhaps the best evidence of its value for practical purposes is the extreme difficulty of finding any experiment which proves that it is insufficient. In spite of this, however, as a dynamical theory it is very unsatisfactory. If, as we are led to do by Ampère, we attach physical importance to elements of current, and regard them as something more than mathematical helps for calculating the force between two closed circuits, then we are driven to ask, not only what is the law of force between the elements, but what is the energy possessed by a system consisting of two such elements ? If we do this, and find this energy by calculating the amount of work required to pull the element an infinite distance apart, we arrive at the conclusion that the energy must depend upon the angles which the elements make with each other and with the line joining them. But if this is so, then the force between the elements cannot be along the line joining them, and there must in addition to this force be couples acting on the elements. For these reasons we see that Ampère's theory cannot give the complete action between two elements of current. What it does, and this for practical purposes is an advantage and not a disadvantage, is to give in most cases instead of the complete action between two elements that part of it which really affects the case under consideration. Before discussing cases, however, in which the terms which Ampère neglects might be expected to produce measurable effects, we shall, in order to compare the various theories more easily, proceed to consider other theories of the same class.

(To be continued.)

CORRESPONDENCE.

THE LAW OF THE ELECTRO-MAGNET AND THE LAW OF THE DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : The interesting paper of Prof. S. P. Thompson, in the January number of the *Phil. Mag.*, has suggested to me the following remarks :—

The theory of saturation of Lamont, as stated, starts from suppositions somewhat similar to those made by me, but differs entirely in its development. It seems to me that Lamont is wrong; and the development of his simplified assumption according to my view leads to an interesting result.

Both views may be represented by supposing the lines of force packed, like wires, into a hole of limited size, which can only receive a certain number. Both views regard the magnetic* conductivity as measured (so far as saturation is concerned) by the portion of the hole remaining unoccupied, or by what I have called the "defect of saturation."

Lamont, according to Thompson's account, then, regards the conductivity as the ratio,

$$\frac{\text{increment of magnetism}}{\text{increment of magnetising force}}.$$

Hence results a differential expression, the integration of which leads to the exponential law obtained.

But this is certainly not the conception of magnetic permeability or conductivity in general use, and it is not that which I employ. Conductivity is the ratio,

$$\frac{\text{magnetism}}{\text{magnetising force}};$$

the ratio of the quantities themselves, not of their increments.

If we make this change, we have, in Lamont's notation,

$$\text{conductivity} = \frac{m}{x} = k(\mathrm{M} - m).$$

M = maximum magnetism.
m = magnetism.
x = magnetsing force.
k = conductivity per unit defect of saturation.

Re-arranging the above expression, we see that it is identical with the form

$$m = \frac{\mathrm{M}kx}{1 + kx}$$

which Prof. S. P. Thompson seeks to derive by approximation from Lamont's exponential expression.

The above may therefore be now regarded as a rational formula, under the same limitations to which it is subject as an empirical one.

My formulæ for permeability (*Phil. Mag.*, February, 1885, p. 89) are

$$\mu = \mathrm{A}\,(\mathfrak{B}\propto - \mathfrak{B})\cos\delta$$
$$\delta = f\,\theta$$
$$\mathfrak{B} = \frac{k}{\rho}\;\frac{60^\circ - \omega\,\theta}{\sin.\,\theta}.$$

Here the A ($\mathfrak{B}\propto - \mathfrak{B}$) represents the

k (M − m) of Lamont, *mutatis mutandis.*

As soon as any attempt is made to represent values of μ (permeability) for the metal, such as are obtained from rings, the introduction of the cos δ, and of the two latter equations between δ, θ, and $\mathfrak{B}$, becomes indispensable. The object of these terms is to represent the initial rise of the permeability, and its passage over into what may be called the saturation fall.—Yours, &c., R. H. M. BOSANQUET.

St. John's College, Oxford.

* The subject of discussion in my theory is the permeability of the metal; in Lamont's, as stated by Thompson, the permeability of the magnetic circuit in a bar. Although I have myself formerly used *permeability* in both senses, I now think it best to speak of *conductivity* in the case of the bar.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : Would you kindly draw attention to a mistake which appeared in your last issue in the report of the Society of Arts meeting, in which an assertion of mine as to the efficiency of secondary batteries was wrongly reported. I was reported to have said that in the tests made at our works with the experimental tramcar it was found that the efficiency in ampere hours was 75 per cent., and in watts 70 per cent., charging and discharging the cells considerably above the normal rate; whereas the figures I gave were 85 per cent. in ampere hours and not 75 per cent.

As the commercial efficiency of secondary batteries is commanding considerable attention, I trust you will find space for the above correction.—Yours, &c.,

BERNARD DRAKE, Managing Engineer.

Electrical Power Storage Company,
4, Great Winchester-street, E.C., Feb. 4, 1885.

THE RECENT TESTS OF INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : My attention has been called to a letter of Messrs. Woodhouse and Rawson, of London, published in your impression of December 11th, and elsewhere, in which they repeat a calumnious statement of a New York paper of June 13, 1885, but omit to add the contradiction by the Secretary of the Franklin Institute, published in the following number of that paper, of June 20, as follows :—

(From the *Electrical Review*, June 20, 1885.)

" Ed. Electrical Review :

" My Dear Sir :—Do me the favour to correct in your next what I take to be an unintentional mis-statement of my remarks regarding the "Electrical Tests" which appeared in last week's issue, and for which I must disclaim responsibility.

" I stated to your representative, as I have invariably stated to numerous other inquirers, that I could give little or no information regarding them, and that the proper person to

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apply to for information was Mr. Tatham. Beyond this, I do not recognise the statements credited to me as my own.

"Yours truly,

"WILLIAM H. WAHL,

"Sec'y Franklin Institute.

"Philadelphia, June 16, 1885."

No other notice, as far as I know, was taken of the article, and the story died of its own absurdity.

The reason given by Messrs. W. and R. for reviving this defunct slander is, that rival makers of incandescent lamps are prodding them with the report of the judges appointed by the Franklin Institute to test the efficiency and duration of incandescent lamps.

It is true that the Swan, the Maxim and other companies did not enter their lamps for the tests for various reasons, but no one had any right or reason to apprehend that they would not be fair tests, and no one now has any reason to say they were not conducted fairly.

In the conduct of the tests the cardinal principle was to do right, and also to avoid all appearance of wrong-doing.

To this end a code was adopted and judges selected, with the full concurrence of the contestants, and nothing was concealed from the parties in interest. The contestants were invited to inspect and did inspect every step in the progress of the tests. Their experts compared the photometric measuring powers of the judges with their own.

I believe it would be impossible to find four men better equipped and experienced for their duties morally, mentally, and physically, than the four judges of these tests.

I was a daily witness of their work, and weekly progress reports of the tests were made to the Franklin Institute.

So much for the general indictment; and now for the particular complaint.

It is, *first*, that their lamps were tested without their knowledge or consent. *Second*, that their lamps were run at five volts above what they were labelled.

Two lots of their lamps were tested. The first lot, selected at random from a barrel of lamps belonging to the Van Depoele Company, were labelled 20 candles, 55 volts. They were tested and run at fifty-five volts. No. 9, with resistance cold of 106 ohms, lived longest, 715½ hours. No. 2, resistance cold 102 ohms, exhibited phenomenal brilliancy.

The complaint that this lot of lamps was entered without their knowledge or consent may be well founded.

The second lot of lamps was received through the Edison Company. I now learn that the origin of this transaction was as follows:—

At a meeting of the London Society of Arts, held December 3, 1884, Mr. Wm. H. Preece, F.R.S., read a paper upon "Electric Illumination," in which appeared the following language (see *Journal* of the Society of Arts, December 5, 1884, page 73):—

"The efficiency of the glow lamps has also been very considerably affected by the improvement made, for instance, by Messrs. Woodhouse and Rawson and by Mr. Bernstein.

"The efficiency of the Edison lamps means the consumption of energy at the rate of five watts per candle, but lamps are now being made which give an efficiency of two and a-half watts per candle with an equal life, which is equivalent to an immediate reduction of 50 per cent. in the amount of energy required to maintain the system alight, and therefore in the cost of production."

Whereupon, the Edison Company challenged Mr. Preece to produce such lamps and have them tested by the Franklin Institute, whose committee was preparing for the tests which afterwards were made.

Mr. Preece procured the lamps and forwarded them to the Edison Company, whose letter dated April 13, 1885, to Prof. Marks (who acted as an executive committee), says:—"Mr. Preece, the electrician of the English Post Office, has sent to Mr. Edison a number of Woodhouse and Rawson lamps. They are now in the New York Custom House. We have given directions to have them forwarded to you at the Electrical Exhibition in the original packing as soon as they are appraised."

At that time our test boxes were all occupied and our current employed.

Inside of the box, when received, was found a large label addressed "for Mr. Wm. H. Preece, 20 candles, 50 volts." The usual label of Woodhouse and Rawson was on every lamp, altered, however, so as to read as above, the figure 0 in the number 50 being written over an erasure. The resistances cold of all the lamps tested were nearly uniform, five at 100 ohms; two, each ninety-nine and 101 ohms, and one 102 ohms. [See Report, Table VI., page 38.]

These circumstances persuaded us that the lamps were not selected by chance.

They were tested and measured for horizontal and spherical efficiency upon the 7th May, both at fifty volts and at fifty-five volts, with the results shown in the following table, which I have made up from the original records:—

WOODHOUSE AND RAWSON LAMPS. (Second lot.)

Measurements of Horizontal and Spherical Efficiency, at 50 Volts and at 55 Volts, Compared. Made May 7, 1885.

Lamp No.	Volts.	Amperes.	Watts.	Candles Averaged.		Watts per spherical Candle.	Watts per Horizontal Candle.
				Horizontal.	Spherical		
30	50·	1·071	53·75	14·19	11·48	4·68	3·79
	55·	1·167	64·18	22·73	18·52	3·46	2·82
31	50·	1·084	54·20	12·38	9·93	5·46	4·38
	55·05	1·182	65·07	20·93	17·28	3·76	3·11
32	50·03	1·084	54·23	12·43	10·47	5·18	4·36
	55·	1·195	65·72	21·28	17·36	3·78	3·09
33	50·	1·089	54·45	14·07	11·75	4 63	3·87
	50·05	1·188	65·40	22·67	19·01	3·44	2·88
34	50·03	1·050	52·53	12·52	10·34	5·08	4·20
	55·	1·147	63·08	20·78	16·91	3·73	3·04
35	49·95	1·046	52·25	14·48	11·73	4·45	3·61
	54·95	1·139	62·58	23·53	19·56	3·20	2·66
36	49·95	1·088	54·35	15·68	13·05	4·16	3·47
	55·	1·191	65·50	25·98	21·41	3.05	2·52
37	50·	1·086	54·33	13·88	11·51	4·72	3·91
	55·	1·185	65·17	22·93	18·74	3·47	2·84
38	50·05	1·097	54·90	12·24	10·05	5·46	4·49
	55·	1·197	65·77	20·70	17·84	3·69	3·18
39	50·	1·089	54·45	11·88	9·73	5·59	4·58
	55·	1·186	65·23	19·74	16·33	3·99	3·41
Average	50·	1·0784	53·944	13·375	11·004	4·941	4·066
Average	55·	1·1777	64·770	22·127	18·296	3·557	2·955

Upon discussing these preliminary results, the judges found it impossible to follow the label. Twenty candles illumination could not be had with fifty volts, and they decided to raise the electromotive force for the following reasons:—There are three points of excellence in incandescent lamps—brilliancy, duration, and economy. The boast for these lamps is that they are brilliant and cheap. It would not benefit their reputation to test them with fifty volts, at which the preliminary tests show that they are both dim and dear, for the sake of increasing their duration, of which the remaining time of the tests, about 300 hours, would furnish no proof.

In this decision the judges were governed by a desire to do for the lamps what they thought the makers would do if they had been present and aware of all the facts. The judges made no concealments of what they did, nor of their reasons for it. They published the results of the tests with fifty volts, but not prominently.

It was out of kind consideration for the makers of the lamps that the judges raised the electromotive force, and it was out of a like consideration that they did not publish a table like the above.

These considerations Messrs. Woodhouse and Rawson have trampled under their feet, and have turned again to rend the committee.

I am unable to see the least shadow of unfairness in the proceedings of the judges, and I ask all those journals which have

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published the letter of Messrs. Woodhouse and Rawson to publish this reply.—Yours, &c., W. P. TATHAM,
President of the Franklin Institute.

INSURANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A friend of mine some time ago was refused insurance against accidents by a well-known company simply because he was an electrical engineer. Of course this action shows great ignorance on the part of the Insurance Company, as an electrical engineer, in nine cases out of ten, is no more liable to accidents than an ordinary engineer.

This action on the part of the Insurance Company referred to reminds me of the fire offices in the early days of electric lighting. Many of them, not understanding the subject they had to deal with, charged 50 per cent. more premiums where houses were lighted by electricity, but when the Phœnix Fire Office went into the matter and found that with proper precautions the risks were no greater in using electricity than with gas, and reduced their premiums accordingly, all the other companies had to follow.

As it is a matter of some moment to us, as electrical engineers, that we should be covered against accidents, I think it would be a great favour if you would allow such information to be given through your columns (either from the companies themselves, or those who *may be* insured) that will enable us to know where, and at what cost, we may be insured. I should like also to know what restrictions, if any, are made with respect to the use of high tension currents.

I think, sir, if you were to express your opinion on the subject of electrical engineers' risks, stating what you consider the greatest E.M.F. that should be allowed as safe, the insurance companies would probably be more ready to accept our proposals, and no doubt on better terms.

Trusting we may have some information on this point, I am, &c., INSURANCE.

THE DYNAMO AS A GENERATOR AND A MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Mordey's letter in your current number, I beg to say that I quite understood that the experiments were made with a shunt-wound dynamo; and I think my letter shows this.

I am, however, unable to understand how the question is affected by the fact of whether Mr. Mordey mentioned a compound dynamo or not.

Mr. Mordey stated in his paper, first, that he had obtained a constant speed, under conditions that were impossible, and then that the speed followed the load inversely, as it must do under the circumstances.

I certainly thought that Mr. Morley intended to refer to the compound dynamo in the first paragraph quoted in my letter, as that is the only form of machine which does maintain a constant E.M.F. at terminals with varying current but at constant speed. And my objection to Mr. Mordey's use of the term "constant field" is as correct for the shunt-wound dynamo as for the compound wound; but with this difference, that where the field in the compound-wound machine increases in strength as the current increases, in the shunt-wound dynamo it decreases. The series dynamo is the only one in which the field is constant; and there the requirements of a varying load are met by variations in the speed of the armature. Where, as in the Edison-Hopkinson dynamo, the resistance of the armature is very low indeed, the shunt dynamo becomes *almost* self-regulating, and the field is *almost* constant; but no shunt-wound dynamo can be so perfectly self-regulating as the compound-wound dynamo, if properly compounded, so long as its armature has a resistance appreciable to the strongest current it will have to carry. Nor can its field be constant except with no resistance and no self-induction in its armature. I am pleased to find that Mr. Mordey has raised the commercial efficiency of the Victoria motor to 80 per cent. I presume that this has been done since he wrote his paper. Unfortunately, his experiments do not show this, unless the unascertained loss in transmission was very serious indeed.

Mr. Sayers' figures, which agree with my own calculations, show that the highest efficiency obtained was 71 per cent., which is *not* commercial efficiency, but something more, inasmuch as no account has been taken of the power absorbed by the field-magnets.

I note that Sir David Salomons, in his letter on "Motors," has given us a very valuable hint for the future.

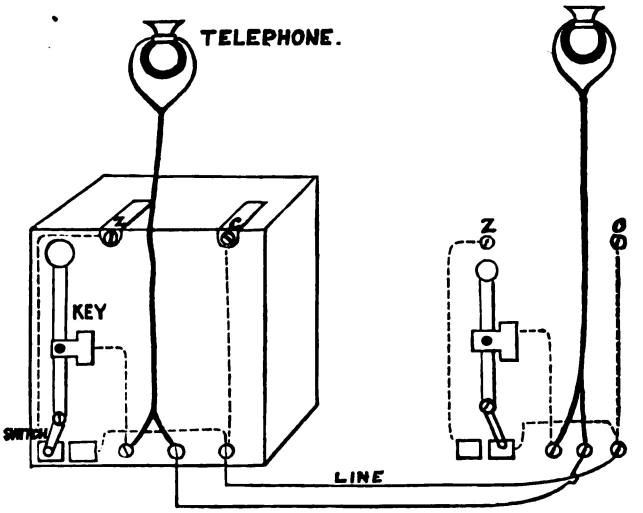
Mechanical engineers always meet us, when we propose that they should run their machines by means of the motors instead of shafting, with the objection that the loss by transmission is too great. "You lose 50 per cent.," they say, "if the machine to be driven is only five yards from the engine," and though your apparatus may do very well for long distances, it "would be absurd to use it in a factory where the distances are so short; and we can transmit by means of shafting and belts with a very much smaller loss." As Sir David has shown, they forget the fact that if only part of the machinery is working, still the whole of the shafting has to run in most cases; whereas, with electro-motors, each machine takes just its own current and no more.

I heard of one large factory in Lancashire where 100 horse-power was allowed for the shafting alone. Fancy the whole of that running, as a *reductio ad absurdum*, to turn a few machines requiring only 2 or 3 horse-power.—Yours, &c.,
SYDNEY F. WALKER.

TELEPHONES AND THE MORSE CODE IN MILITARY OPERATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On receiving *The Electrician* of November 27th, 1885, I noticed a communication from J. H. A. Macdonald, Edinburgh, concerning the use of telephones and the Morse code in military operations.



I have used this instrument and code as a means of temporary communication for distances up to two kilometres. I attach a sketch of connections as I used them. Fig. 1 represents a small battery of 1, 2, or 3 small Leclanchés in a well-closed box, 5 x 2 x 2in., or larger, as 1, 2, or 3 cells are used; on the box is fixed a key for breaking circuit, at the back of box is a hook for securing it to manipulator's belt. Each manipulator is supplied with box complete, but as battery at one end only is in use, key is supplied with a switch to put battery in or out of circuit, according to previous arrangement.

Fig. 1 shows battery switched in, whilst Fig. 2, at other end of line, has only circuit breaker in use.

With this instrument secure on right side of belt, manipulator keeps telephone to left ear, and uses right hand for speaking.

If you think this worth anything I shall be glad if you will publish it.—Yours, &c.. JACARE.

Fortaleza, 7th January, 1886.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE TELEPHONE QUESTION IN AMERICA.

To understand the present position of telephone affairs in America is difficult for those who are not acquainted with the ways of the United States Patent Office and of American Courts of Law; how "interferences" can be declared between rival patentees; how local "injunctions" can be moved for and ordered by the judges in the various States of the Union; how "evidence" can be brought before the courts in a manner which the laws of evidence in this country would utterly exclude; how patent law is often construed with the view of giving "protection" to the Yankee inventor as against the prior inventions of a foreigner; and how, in general, the methods of wasting time in the law's delays are even more abundant than in the old country.

It is amongst such conditions as these that the promoters of the American Bell Company have worked. They have bought up the interests of one rival who was "in interference;" ompromised with another; obtained a local judgment against another; used this judgment against the next comer, and so redoubled their forces upon the next; every decision in their favour having helped to widen their claims and to embolden them in their pretensions. For a good many months it has been evident to careful observers on this side of the Atlantic that such a state of things was becoming intolerable. At last it was whispered that the peculiar legal machinery of the United States, which enables a suit to be brought in the name of the United States to test the validity of an important claim, would be put in motion against the American Bell Company. After several puzzling manœuvres, the meaning of which does not appear upon the surface, on the application of a United States District Attorney of Baltimore, the Secretary of the Interior Department at Washington, Mr. Lamar, has decided that a suit of this kind shall be instituted.

On learning this decision, Prof. Graham Bell took the step of addressing a letter to the Attorney-General of the United States. As this officer will be the virtual judge as to whether there be a *primâ facie* case or not, the sending of a letter to him constitutes in itself a most extraordinary circumstance, and one which, had it occurred in England, would be regarded as a serious contempt of court, punishable by heavy penalties as being a gross attempt to influence the Court before the hearing of the case. The letter itself is scarcely less extraordinary. It is distinctly angry in tone, and personal in several respects. It contains many *ex parte* statements such as no court could for a moment accept, even if the communication were itself in order. Far better had it been for Prof. Bell to have kept silence at this stage, rather than appear to endeavour summarily to burke a judicial investigation of his claims. His letter, which, though sent to England as a private communication, has been printed in full by a contemporary, consists of three principal parts: A statement of certain decisions of local courts, and of the Patent Office to the effect that the art of transmitting speech by electricity (which entire "art" is now claimed by Bell) was not to be found in any of the publications relating to Philipp Reis's telephones; a statement, personal and largely *ex parte*, respecting the inventions of his rival, Mr. Elisha Gray; and a still more personal statement about certain parties, whom Bell styles "convicted infringers," whom he alleges to have instigated the present suit. With these last persons we have no concern. It matters little who the individuals may be that have brought the issues to a head; our interest is with the issues themselves. With respect to the claim of Bell to the entire "art of transmitting speech by electricity," we have much more to do. That such a prodigious claim could be founded on the very narrow language of the original Bell patent is a monument to the adroitness of New England lawyers. To sustain such a claim an inventor must show not only that he is the first, but that he is the *sole* inventor of the art. He must show that there is no other way of doing it than that which he invented. And it seems to us that this is a task which is beyond human capability. Was Bell the first? Is his method the only possible method of transmitting speech by electricity? These are the two essential points. He has himself named Philipp Reis—Reis, the deceased schoolmaster, who, to use Bell's own words, "entered the field of telephonic research" in 1861, and died, all too soon, in 1874. Thanks to those who have been most active in rescuing Reis's words and works from undeserved neglect, we now know how much he had done. In 1861 he wrote that he had "not yet succeeded in transmitting human speech with a distinctness to satisfy every one"; nevertheless he persevered, and in 1863 he was able to write: "I assure you that when you visit me here I will show you that you are in a position quite to understand words also." Others who bought Reis's telephones allege that they were able then, and are able now, to use them to transmit speech. These facts if established as against the claim to the whole "art," will go far to upset Judge Gray's decision, which was the first of so many others in local American suits, that "a century of Reis would never have produced a speaking telephone." Bell has also named Elisha Gray, but seems to forget that at the Paris Exhibition of 1878, it was to Elisha Gray, not to Graham Bell, that the award was made for the invention of the telephone.

Secondly, is Bell's method of transmitting speech by electricity so absolutely comprehensive as to preclude the possibility

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of any other? Not even a United States Court, be it ever so wise or just, can set limits to inventive genius and say, "thou shall not invent." Let us inquire what Bell's method, *as claimed by him in 1876*, was. The method was clearly set forth in three claims as essentially one of "producing undulations in a continuous voltaic circuit." The only method previously known was that of Reis, whose method consisted in opening and closing the voltaic circuit in proportion to the vibrations, by a transmitter having a diaphragm combined with a loose contact arrangement, which can be best described in modern language as a metal microphone. The advocates of Reis's claims have not failed to point out that the words "make-and-break," so often attributed to him, were never used by Reis, and that the action which he described as opening and closing the circuit differed in degree only, not in kind, from the action in every modern battery transmitter such as the "Blake" instrument. As a matter of fact, throughout the United States, though Bell's later form of instrument is used as receiver, Bell's instrument is not used as a transmitter; his instrument and his method have for that purpose been abandoned. The transmitter actually used is the Blake, and its method of operation closely resembles that of Reis; it opens and closes the circuit of a battery in proportion to the vibrations. Reis's method of transmitting speech by electricity being previously known, it is clear that if Bell's claim of 1876 does not include Reis's method, it excludes it. Such at least is the contention of Reis's friends, and, according to them, if Bell's claim includes Reis's method, then Bell's claim is bad. If Bell's claim excludes Reis's method, then it is useless for the advocates of Bell to claim the entire "art" of electric transmission of speech.

There are other issues of course besides this. There is the question whether such undulatory currents as Bell described in 1876 can possibly convey anything more than musical and vocal sounds. It is asserted by some that to transmit perfect articulate speech with all its consonants and abrupt turns of inflexion, an intermittent and not an undulatory current is absolutely necessary. This is again an issue too wide to be traversed here, but it is one of the many questions which will presently be brought under review in the fierce light that beats upon a law suit. Our readers will doubtless await the hearing of the suit with an interest the more eager because of the magnitude of the claim which has been so elaborately built up, and of the hitherto unchecked triumph of the monopoly which controls the telephone from the Atlantic to the Pacific. We have hitherto been among the foremost to do full justice to Prof. Bell's invention, but we are unable to follow him in the extravagant claims now put forward in his letter to the United States' Attorney-General, or to sympathise with the angry and aggressive tone which pervades it.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: *The Electrician* of the 22nd and 29th inst. having been published without any reply appearing in them from Dr. Stone to my letter published in *The Electrician* of the 15th inst., it is now my duty to expose the fallacy of the imputations Dr. Stone emitted against the electric boy in his letter in *The Electrician* of the 8th inst. Dr. Stone's allusion to dry climates, like some part of America, and electricity produced by walking on carpets therein, is altogether erroneous as regards the case of the electric boy. When I saw him the weather was wet and of the most unfavourable kind for the manifestation of electricity by such means. Again, the piece of carpet in question was not more than two square yards in extent, so that there was no room for such an amount of walking as would be necessary for such an effect to be produced. Again, if the electricity manifested in the boy's body came up from his feet, his legs, when touched, ought to have given a shock stronger, or as strong as that obtained from his body; but the opposite of this was the case. I felt no shock when I touched his legs, but received a shock when I touched the upper part of his body, and especially when his tongue was touched. These facts are utterly inconsistent with Dr. Stone's insinuations, and, on the contrary, the facts I have just stated of my own experience with the electricity manifested from the boy's body cannot be explained on the supposition that the boy was electrified from a source external to his own body. I particularly request Dr. Stone's attention to these facts. There is a most important source of electricity in the human body, which, as far as I am aware, has never been referred to by any writer on electricity, namely, the breath we draw into our lungs. It consists of oxygen, nitrogen, ozone, as commonly stated. But each of these substances contains a goodly quantity of electricity which at each breath is taken into the lungs, and although a portion of it will go out again by the expired breath, still a large portion of the inhaled electricity must go to help to keep up the internal heat of the human body. And if our skins were perfect non-conductors of electricity and we did not perspire, electricity would accumulate in our bodies to an inconvenient extent. Since this correspondence began, a scientist has informed me that the electric boy's case is not a solitary one. There are other persons in whose bodies electricity is developed in a mysterious way; but private individuals do not like their electrical infirmities made the subject of public observation.

As to your correspondent "Hamlet," the contents of his letter are so fabulous that they bear, on the face of them, their own condemnation.—Yours &c.,

8, Merchiston Park, JAMES JOHNSTONE.
Edinburgh, 30th January, 1886.

THE CALORIMETRIC MEASUREMENT OF INCANDESCENT LAMPS.*

BY WILHELM PEUKERT.

An important advantage of the electric light as compared with other systems of illumination, lies in the relatively far smaller amount of heat developed by the former for an equal intensity of light. Accurate calorimetric measurements of incandescent lamps have not yet been made public, and the results obtained with such lamps are therefore given below, whilst I reserve for a future occasion a report on corresponding experiments with arc lamps. The experiments may be of interest from another point of view, as they enable us to form a conclusion as to the economical utilisation of the electric energy consumed by a lamp. The working of a lamp, other circumstances being equal, must be considered the more rational the greater the proportion of the electric energy absorbed which reappears in the amount of light generated.

The experiments have been conducted in the electro-technical laboratory of the Technical High School at Hanover, and it is my pleasant duty to put on record my obligations to Prof. Dr. W. Kohlrausch, who placed at my disposal the necessary apparatus, as well as to Herren Caspari and Ottesen, who took part in the measurements.

The determination of the heat evolved by the incandescent lamps was effected by means of a calorimeter. This consisted of a large beaker of thin glass, which was filled each time with a quantity of water carefully weighed.

The incandescent lamp in question was immersed in the water, which was continually kept well mixed by means of a simple agitator, and possessed a uniform temperature. This temperature was observed on a thermometer placed in the calorimeter, graduated in tenths of a degree centigrade. The calorimeter was fixed on a heat insulator, and to avoid as far as possible losses of heat to the surrounding air, a very slight difference between the respective temperatures of the air and the water was maintained during the experiments, amounting

* From *Zeitschrift für Elektrotechnik*.

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to 5° C. in one case only, and being in others always below this maximum value. That, in fact, the increase in the temperature of the water was little affected by the temperature of the air, is shown by the following rises of temperature taken at equal intervals of time, which in few cases differ by 0·1° C. The temperature of the work room increased only by 1° C. during the entire time of the investigation.

To ascertain the absorption of light, every lamp was determined photometrically, both when exposed freely and when placed in the calorimeter. As a standard of comparison I used Von Hefner-Alteneck's normal flame. The current was furnished by a Schuckert compound machine driven by a well-regulated Otto gas engine, so that the potential difference at the lamps, measured with a Siemens and Halske torsion-galvanometer, remained very constant. The strength of the current was determined with the same instrument by ascertaining the difference of potential at the ends of an accurately known resistance.

The results obtained are as follow :—

Siemens and Halske Incandescent Lamp.—The lamp worked with a potential difference of 98 volts and a strength of current of 0·554 ampere, which values were found as the mean of all the observations executed simultaneously, which, as already mentioned, differed little from each other.

The calorimeter contained 2,471 grms. of water, and if we calculate the value of the vessel in water as 79·1, the total quantity of water was 2,550·1 grms.

The observations were made at intervals of three minutes.

This rise of temperature of 0·7° in three minutes gives an hourly development of heat of 35·7 kilogram calories.

Thermometer.	Rise of Temperature.
14·9°	0·6°
15·5°	0·7°
16·2°	0·8°
17·0°	0·7°
17·7°	0·7°
18·4°	Mean......... 0·7°

The lamp when burning freely gave a light of 8·8 normal candles, and when in the calorimeter, 8·1.

Edison's Incandescent Lamp.—Potential difference at the lamp = 93·6 volts ; strength of current = 0·963 ampere.

Total quantity of water, 2,791·1 grms.

Observations at intervals of five minutes.

Thermometer.	Rise of Temperature.
14·65°	1·65°
16· 3°	1· 7°
18· 0°	1· 6°
19· 6°	1· 7°
21· 3°	1· 6°
22· 9°	Mean .... 1·65°

The rise of temperature of 1·65° in five minutes gives an hourly development of heat of 55·26 kilogram calories.

The lamp, burning free, gave a light of 16·9 normal candles, and in the calorimeter 14·4 normal candles.

Swan's Incandescent Lamp.—Potential difference = 76 volts; current = 2·552 amperes. Quantity of water, 2,435·1 grms. Observations every two minutes.

Thermometer.	Rise of Temperature.
15·1°	1·7°
16·8°	1·7°
18·5°	1·7°
20·2°	1·7°
21·9°	1·7°
23 6°	Mean .... 1·7°

A rise of temperature of 1·7° in two minutes represents an hourly development of heat of 124·19 kilogram calories. The lamp, burning free, gave a light of 30 normal candles; in the calorimeter, of 28·2 normal candles.

Bernstein's Incandescent Lamp.—Potential difference = 48 volts; current = 3·934 amperes. Total quantity of water, 2425·1 grms. The observations were made at intervals of two minutes.

Thermometer.	Rise of Temperature.
15·5°	1·1°
16·6°	1·1°
17·7°	1·1°
18·8°	1·1°
19·9°	1·1°
21·0°	Mean......... 1·1°

The rise of temperature of 1·1° in two minutes gives an hourly development of heat of 80 03 kilogram calories.

The lamp, burning free, gave a light of 52·1 normal candles, and in the calorimeter 51 normal candles.

Concerning this lamp, it must be remarked that the quantity of heat as determined is possibly too low, since losses of heat were not absolutely excluded in the experiment, owing to the construction of the lamp, which could not be entirely immersed in the water.

As the electric energy consumed by an incandescent lamp is converted into heat and light only, the portion of the total work of the current equivalent to the light evolved may be determined approximately, if not with absolute accuracy. An experiment may here be mentioned which was performed with an Edison A lamp.

It was placed in the calorimeter along with a vessel of thin sheet copper, so that light and heat were kept back. The amount of heat determined in this case agreed to 2 per cent. with that calculated from the potential difference and the strength of the current.

If we may assume that in the first-mentioned experiments the entire heat developed was absorbed by the calorimeter, and that the heat lost in the air was but small, which, approximately speaking, was the case, we obtain from the quantity of light evolved by the various lamps the following equivalent quantities of heat:—

Siemens and Halske's Lamp.

	Kilog. calories.
Hourly quantity of heat corresponding to the work of the current	46·98
Heat equivalent to the light evolved	11·28
Hourly heat per normal candle	1·393

Consequently for this lamp, with reference to the absorption of light, the heat evolved hourly may be estimated at 37·73 kilogram calories, corresponding to 74 per cent. of the total work of the current, so that 26 per cent. of the current falls to the quantity of light evolved.

Edison's Lamp.

	Heat units.
Hourly amount of heat corresponding to the work of the current	78·01
Heat equivalent to light evolved	22·75
For normal candle hourly	1·58

Thus the heat evolved hourly by this lamp may be taken as 51·31 heat units. Hence 66 per cent. of the work of the current are expended in heat and 34 per cent. in light.

Swan's Lamp.

	Heat units.
Hourly amount of heat representing work of current	167·86
Heat equivalent to light evolved	43·67
Therefore for a normal candle hourly	1·549

The heat evolved by this lamp hourly is 121·4 heat units. Hence 72 per cent. are expended in heat and 28 per cent. in light.

Bernstein's Lamp.

	Heat units.
Hourly amount of heat representing work of current	163·43
Heat equivalent to light evolved	83·4
Therefore hourly per nominal candle	1·635

The hourly heat for the lamp is therefore 78·24 heats units. Of the total work of the current, 48 per cent. is expended in

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heat and 52 in light. This high percentage may be due to the circumstance that, as already mentioned in the experiments with this lamp, considerable losses of heat were not excluded. Indeed, the percentages of the work of the current assigned here to the production of light can only be regarded as the superior limit. Experiments more precise than those here described may possibly yield lower values.

If the hourly quantities of heat per unit of light are calculated into their equivalents of mechanical work, we obtain the mechanical work per second equivalent to a unit of light (and therefore for a magnitude which may be regarded as the mechanical equivalent of this light), the following values: 0·16 kilogrammes (Siemens and Halske), 0·18 (Edison), 0·18 (Swan), and 0·19 (Bernstein). These values show a sufficient agreement for the experiments just described, but can by no means be regarded as giving an accurate value for the mechanical equivalent of light. Indeed, the experiments were not conducted with any such intention. These results are merely mentioned here as a corollary of the experimental conclusions, perhaps not quite devoid of interest.

For the sake of comparison, the amounts of heat obtained with other sources of light are tabulated along with those found with incandescent lamps. The hourly quantities of heat evolved are :—

	Heat units.
Incandescent lamps. Siemens and Halske...	427
" " Edison	355
" " Swan	430
" " Bernstein	153
Gas. Siemens' regenerative burner	1,500
" Argand	4,860
" Two-hole burner	12,150
Petroleum. Round burner	3,360
" Small flat burner	7,200
Solar oil. Schuster and Bauer's lamp	3,360
" " Small flat burner	7,200
Rape oil. Carcel lamp	4,200
" " Reading lamp	6,800
Paraffin candles	9,200
Spermaceti candles	7,960
Wax candles	7,960
Stearine candles	8,940
Tallow candles	9,700

The above-mentioned experiments have led me to undertake a close investigation into the conversion of electric energy into light and heat, both in incandescent lamps and arc lamps. A memoir on this subject will shortly appear.

DYNAMO TESTS.

(Continued from page 216.)

Power Measurements.

The general principle of the Tatham dynamometer is shown in Fig. 6. The power applied to the shaft on which the driving pulley D is fixed, is transmitted to the pulley B, to whose shaft the machine to be tested is coupled, by an endless belt, which passes over D, under the stretching pulley S, over the weighing pulley W, under B, over the second weighing pulley W, under S, back to the place of starting. Each of the weighing pulleys W is supported in a cradle, the outer end of which is pivoted on the knife edge F, while the inner end is supported by the link L C. The upper ends of the two links are fastened to the scale beam F, P at equal distances from and on either side of the fulcrum F.

To calculate the power applied to the pulley B, it is necessary to know three things: The difference of tension of the belt on the two sides of B; its effective diameter; and its number of revolutions. These will be discussed in order.

The scale beam is acted upon through the links L C, fastened to the cradles of the weighing pulleys W. The tensions of the belt on the outer faces of these pulleys have no effect on the beam, since the line of effort of the belt passes through the knife edges F. The only forces, then, that act on the beam are the two tensions of the belt on the inner faces of pulleys W, *and these are the tensions on the two sides of* B; and the links being at equal distances on either side of F, the *difference of the tensions* is recorded on the beam.

The scale beam was of steel, graduated by Brown and Sharpe into 600 divisions. With the weight used each division meant one half-pound. A small poise travelling on the weight allowed readings to be taken to $\frac{1}{200}$th of a pound.

There were two adjustments to the cradles. In the first, the axis of the pulley W was moved by micrometer screws to such a position that the line of effort of the belt passed through the knife edges of the cradle. To show this, the pulley was chocked, a short piece of the belting hung on its outside face, and weights placed in a pan hanging to the belt. When there was no effect on the scale beam, the adjustment was accomplished.

The second adjustment determined the position of the knife edge to which the links were connected. This was moved until the beam weighed about 250 pounds correctly to within one-twentieth of a pound.

The pulley B was calculated to deliver 6·6 feet per revolution, but the belting used was thicker than was at first intended, and the value 6·6 should be increased by one-fourth per cent. The effective diameter of the pulley, including the thickness of the belt, was measured directly, and also calculated from the the length of belt delivered by five turns of the pulley. For the latter measurement, two steel points, one of which was fitted with a micrometer screw, were fixed on a wooden rule, and their distance apart accurately determined on a standard scale. Marks were made on both the pulley and belt opposite to fixed pointers. Five revolutions were given the pulley, and the length of belt that passed the pointer was measured by the rule with the steel points, any margin being taken off by a pair of compasses. The pulley was turned both ways and the effect of stretching eliminated.

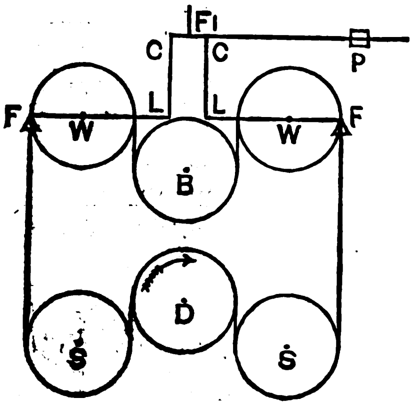

Fig. 6.

The two methods checked very closely, and gave for the delivery of the pulley

6·6 (1·0025) feet per revolution.

A very ingenious mechanical counter registered the number of revolutions. Observations could be taken each minute, and the counter recorded continuously to 1,000,000 revolutions.

Having the difference of tension on the two sides of B, its delivery per turn, and number of turns per minute, the horse-power is calculated as follows :—

$$\text{Horse-power} = \text{divs. scale beam} \times \text{No. revs.} \times \frac{6\cdot6\ (1\cdot0025)}{2 \times 33000},$$

$$\text{Horse-power} = 1\cdot0025 \left\{ \frac{\text{divs. scale beam} \times \text{No. turns per min.}}{10,000} \right\}$$

It will be seen that the only part of the friction of the dynamometer that appears in the readings is that due to the bearings of the pulley B. By the principle of Morin, that the sum of the tensions on the two parts of the belt is constant, this friction should be the same whatever the load. In getting the power applied to a machine, after the measurements have been made with the machine coupled to the dynamometer, it was uncoupled and the dynamometer run at the same number of revolutions, the scale beam observed, and its reading subtracted from the reading when coupled.

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To avoid the uncertainty of loss due to belting, the shaft of the driven pulley B was coupled directly to the dynamo by a universal coupling. It was assumed that this would allow for any slight inexactitude in lining the dynamo and the dynamometer shafts, but it is doubtful if it was of much value at the high speeds used for the tests.

The figure of the dynamometer (Fig. 7) gives a view of it as used in these tests. The automatic recorder for the scale beam, shown in the figure, was not used. In making observations, the number of revolutions and scale beam were read each minute, usually for ten minutes. The means of the two sets were multiplied together, the product divided by 10,000, and a correction of one-fourth per cent. applied, as given in the formula.

The delicacy and range of the dynamometer were both very great. On one occasion the power absorbed by a single Weston mammoth lamp was accurately measured, while the slightest variation of the load could be at once detected. During a test, the scale beam usually floated steadily, the slight and rapid jar caused by running served to limber up the weighing apparatus and render it especially sensitive. Indeed, it would be hard to fix a limit to the accuracy with which the observations could be taken.

Mr. Tatham has published a paper* giving the principles involved in the dynamometer, and describing its various modifications of form.

The engine used was a 10in. by 20in. Salem Buckeye. Its governor adjustment could be readily varied from 100 to 200 revolutions. The speed, under the steady load of a dynamo, was very uniform.

A steel boiler, loaned by the Baldwin Locomotive Works, was used. It could safely carry 150 pounds per square inch and develop eighty horse-power.

* *Journal* Franklin Institute, Dec., 1882. Vol. CXIV.

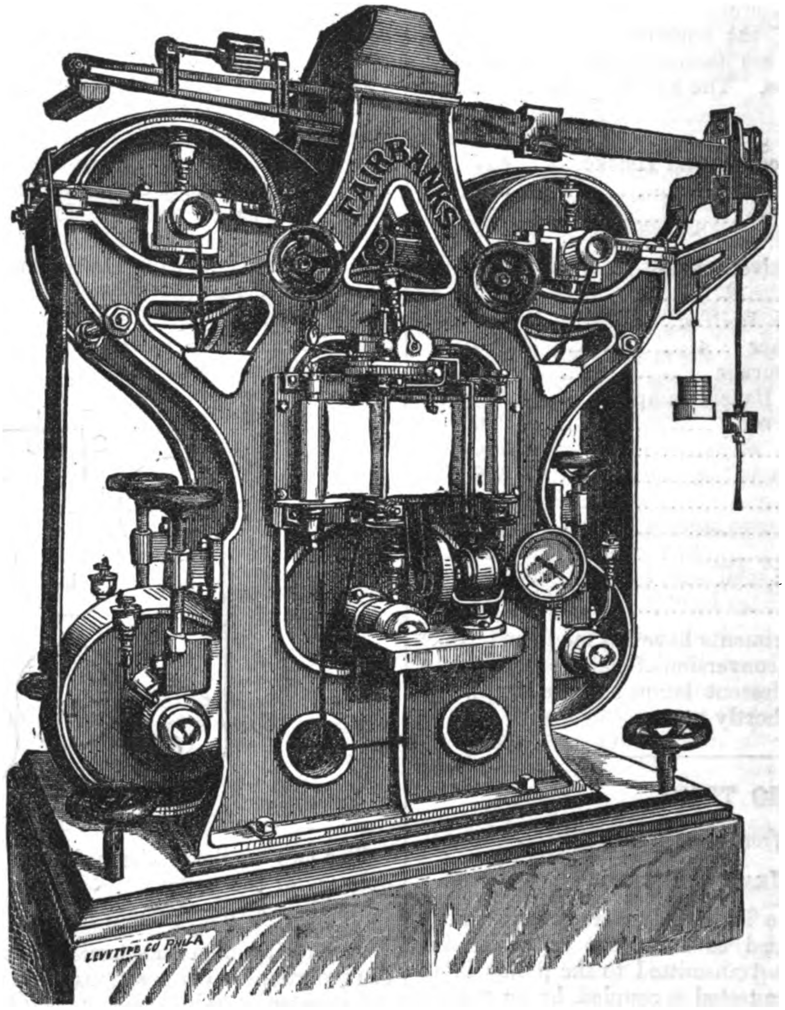

Fig. 7.—The Tatham Dynamometer.

Checking the Dynamometer.

In order to make the tests absolutely, as well as relatively accurate, it was decided to check the work recorded by the dynamometer against an amount of work calculated from the mechanical equivalent of heat.

To do this, a calorimeter was constructed.

It was of wrought iron 3ft. long by 3ft. in diameter, with V-shaped projections riveted inside the shell. The paddles, 30in. long by ½in. thick, were keyed to the shaft and moved between the V's. One end of the shaft passed through the end of the calorimeter, and was coupled to the dynamometer. In the experiments but one paddle was used, 700 revolutions absorbing about forty-five horse-power.

Two different methods of experiment were employed; first, with a constant weight of water and an increasing temperature; and second, with a constant temperature and a continuous flow of water through the calorimeter.

First Method.—In the first method, the calorimeter was filled and its water equivalent found, the engine was then started, and the rise of temperature noted, and the dynamometer observed. The mechanical equivalent was calculated from the work recorded by the dynamometer, the water equivalent of the calorimeter and the rise of temperature, the necessary corrections being applied to the latter. The value thus obtained was compared with the values of Joule and Rowland.

In getting the water equivalent, the calorimeter was first weighed empty, and then when filled with water. The difference gave the weight of the water, and the water equivalent of the iron was calculated from its weight and specific heat.

(To be continued.)

Great Northern Telegraph Company.—The traffic receipts of this company for January amounted to £19,880.

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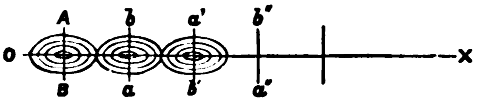
CLERK MAXWELL'S ELECTRO-MAGNETIC THEORY OF LIGHT.*

BY MISS J. M. CHAMBERS, B.SC.

The following is how I have supposed the "series of oppositely directed magnetisations and electromotive forces" of C. Maxwell's theory to arise. I do not in the smallest degree pretend to comprehend his mathematics, and it is only from his verbal explanation that I have formed the following conception of what his meaning is.

Suppose we have a straight linear conductor, A B, in which from some cause or another a quantity of electricity is continually bobbing up and down. We know that the lines of magnetic force, arising from these alternate up and down currents, will be circles having the linear conductor for axis. Suppose we have a row of these conductors parallel to one another.



When the magnetic force lines cut the next conductor *ba*, an electromotive force of opposite sign to that in A B will be engendered, in accordance with Lenz's law, and a current will ensue which will in its turn be surrounded by magnetic force-lines. When the current in A B is reversed, the induced one in *a b* will be so too.

The action of *a b* on *a' b'* will be the same as that of A B on *a b*; and the same effects will be propagated along the whole line of molecules. We have here the electromotive forces and the magnetic forces acting in directions perpendicular both to one another and to the direction of propagation, O X, as the theory requires. Of course this explanation would be for a plane-polarised ray.

It seems to me that this explanation presents to the non-mathematical mind, in a tangible form and in accordance with well-known electrical phenomena, what may be the manner of production of the "series of oppositely directed magnetisations and electromotive forces."

It is not necessary that the conductors should be linear; we may suppose them globular and touching one another, without interfering with the idea of the action above explained. We may, in fact, suppose them merely portions of the æther.

Perhaps it may be objected that my conductors are not circuits; but a current which keeps passing backwards and forwards from a condenser acts in precisely the same manner as a true current (*see* Art. 776 Maxwell, &c.), and why not also without the condenser?

Note.—Perhaps this idea is nothing new, and has occurred to others as well as to me. I have been told, however, that C. Maxwell himself would never precisely define the action by which he supposed light and electromagnetic induction propagated.

* "A Simple Way of Explaining Clerk Maxwell's Electro-Magnetic Theory of Light." From the *Phil. Mag.* for February.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

PRESIDENTIAL ADDRESS.

BY PROFESSOR D. E. HUGHES, F.R.S.

Before commencing the subject of my address this evening, I desire to express my sincere thanks to the members of the Society of Telegraph-Engineers and Electricians for the great honour they have conferred on me by electing me as their President, and to assure them that I will do all in my power to aid and promote the interests of our Society, which are those of applied science in one of its highest branches. It is the custom in our Society that the elected President should open the Session by an address containing a general review of the present state of Electrical Science, or researches in some special branch which may be of interest. I have chosen the latter, as it enables me to present to you some researches which I have not yet published, and I propose to present these in the form of a paper rather than an address, in order to allow our members the opportunity of a full discussion on the subject, which I hope may bring forth many new facts in their possession.

The subject which I have chosen is—

THE SELF-INDUCTION OF AN ELECTRIC CURRENT IN RELATION TO THE NATURE AND FORM OF ITS CONDUCTOR.

Induced or secondary currents in a near but independent circuit were discovered by Faraday in 1831; and the phenomenon of the self-induction of an electric current in its own wire was observed by Henry in 1832, and traced to its cause in 1834 by Faraday, who proved that on sending a current through a wire a momentary induced current in the opposite direction is evoked in its own wire; also that, on the cessation of the primary current, a second induced or "*extra current*" is excited in the direction of the primary. The effect is greatly augmented when the wire forms a coil, as we then have in addition the reaction of superposed currents; but the effect exists to a great extent even when the wire forms but a single loop, or a straight wire with the earth forming the returning portion of the loop, as in all telegraph lines. It has been generally supposed that the nature of the molecular condition of the metal through which the primary current passed exerted no influence upon the extra currents except that due to its resistance. I have previously pointed out* that for induced currents "the rapidity of discharge has no direct relation with the electrical conductivity of the metal, for copper is much slower than zinc, and they are both superior to iron." This led me to make a study of these extra-currents, for which purpose I constructed a special induction bridge, in order to measure both the primary and its extra-currents separately at the instant of action.

Induction Bridge.—This instrument is a combination of a portion of my "Induction Balance," with a "Wheatstone Bridge." The resistance of the wire is measured and balanced by the bridge; the induced or extra-currents are measured and reduced to zero by an equal opposed induced current from the induction balance.

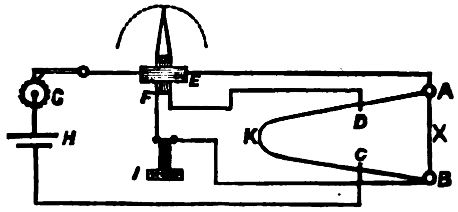


FIG. 1.

The above diagram shows the electrical communications. The bridge consists of a single German silver wire (0·25 mm. diameter, 1 metre in length, of 4 ohms resistance) running from A to K, returning to B. The wire is stretched and sustained upon two wooden arms articulated at K, by means of which the terminals A B can be more or less separated as desired. The wire to be tested, X, is joined at A and B, thus completing the closed circuit of the bridge. The external communications are shown, A being connected to the primary coil of the sonometer E, and through it to the spring of the interruptor or rheotome G, the interrupting wheel being connected to the battery H, and thence to the bridge at C. The wire from B passes through the telephone I to the secondary coil F, returning to D.

Great care has to be taken in the construction of the bridge, so that it shall be as free as possible from induced or extra-currents; and for this reason we cannot employ or introduce resistance coils. The resistance of the wire X is balanced by sliding the communications D and C. It is evident that if all the arms of this bridge are equal in resistance and inductive capacity, there will be silence on the telephone; but if A B be slightly stronger or weaker in inductive capacity, then we may be able to balance its resistance, but not its induction, as we shall then have a slight or a loud continuous sound due to the differential extra-currents in the arm A B. These are compensated by the introduction in the circuit of the telephone of an equivalent but opposed induced current from the secondary coil of the sonometer F, the degree of angle through which this coil has turned to produce silence being the degree of force of the extra-current. The induction sonometer† consists of two coils only, one of which is smaller and turns freely in the centre of the outside coil. The exterior coil being stationary, the centre coil turns upon an axle by means of a long (20 cm.) arm, or pointer, the point of which moves over a graduated arc or circle. Whenever the axis of the interior coil is perpendicular to the exterior coil no induction takes places, and we have a perfect zero; by turning the interior coil through any degree we have a current proportional to this angle, and in the direction in which it is turned. The value of the induction current for each sonometric degree was $\frac{1}{1000}$ of the primary current which passed through the wire under observation, the latter being variable at will from ·001 to ·250 ampere. There is also a reversing key (not shown in the diagram), in order to place the interruptor on the telephone circuit and close the battery current from H to A; the conditions then being the usual method of testing, except using the telephone in place of a galvanometer—a well-known method. The telephone, being exceedingly sensitive and rapid, is most suitable, whilst a galvanometer would be too slow, and its use, in fact, impossible for the researches I have been making. Numerous details have been necessarily omitted in this rough sketch of the instrument. Suffice it to say that it is perfectly adapted for the object sought, viz., the investigation and measurement of the self-induction which takes place in all wires.

* "Induction-Currents Balance," *Proc. Roy. Soc.*, Vol. XXIX., p. 56, 1879; "Molecular Electro-Magnetic Induction," *Proc. Roy. Soc.*, March 7, 1881.

† *Comptes Rendus de l'Académie des Sciences*, Paris, Dec. 30, 1878, and Jan. 20, 1879; *Proc. Roy. Soc.*, Vol. XXXI., p. 527, 1881.

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By all previous methods the measurement of the resistance of a wire is taken when the current has been already some time in action, or, to use an expression of M. Gaugain, when the electricity has arrived at its "stable period." In telegraphy, electric lighting, and all applications using rapid electrical changes, another period has to be considered—viz., that during the rise and fall of the current; this he named "the variable period," and it is in this period that all the phenomena of induction take place. To observe the *stable* period, the current is continuously passed through the bridge (and consequently through the wire under observation), and the interruptor being placed in the telephone circuit allows us to find the exact resistance of the wire, free from all induction or change in the wire itself. To observe the *variable* period, the interruptor or rheotome (making at will from 10 to 100 contacts per second) is placed on the battery circuit, the telephone being joined as shown in the diagram. By means of a switch or reversing key these changes are made as rapidly and often as desired.

If there were no static or self-induction, no loss of time, or change of resistance, then the result from these two periods would be equal; but this is never the case, for we find that when the resistance is balanced to a perfect zero for the stable period, loud sounds are given out in the variable period, requiring a fresh adjustment or balancing of the resistance of the wire, as well as a compensating opposing induction current from the sonometer to balance the self-induction. If we balance the resistance or the extra currents alone there is no possible zero, but when both are compensated we find at once a perfect zero for the resistance of the wire, and for its extra currents.

Inductive Capacity of Metals —The results of the following experiments prove that the force and duration of the extra-currents depend upon the kind of metal employed as a conductor, its molecular condition, and the form given to the conductor, independent of its resistance or the electromotive force of the primary current. The increase of force by increased length is proportional to the length of wire less its additional resistance, but with wires of the same length increased cross section or diminished resistance does not produce a corresponding increase in the electromotive force of the extra currents. The time of charge and discharge of the wire is independent of the electromotive force of the extra currents; for, if we compare currents of equal electromotive force obtained from copper and iron, it will be found that the duration of these currents in wires of 1 mm. diameter will be seven times slower in iron than in copper, and a still greater difference will be found in larger wires. The longest or slowest charge and discharge take place in the purest soft iron, and have a constant ratio of increase with increased diameter of the wire; my experiments giving for wires of double the previous section, or for wires of four times less resistance, a mean increase of three times its previous duration. The electromotive force of the extra current in different metals will be seen in the following table, and in order that the values obtained from the sonometer may be clearly understood I have reduced the results to comparative values. The table of values was obtained on wires of similar length, having been repeated on a similar series of lengths ranging from 10 cm. to 5 metres. The instrument is sufficiently sensitive for pieces only 10 cm. in length, and the results from the short lengths were as pronounced and accurate as those for greater lengths. I may add that the instrument shows no effects or traces of static charge for the lengths mentioned.

TABLE I.—Wires 1 mm. in Diameter, 30 cm. in Length.

Soft Swedish iron	100	Copper	20
Soft puddled iron	78	Brass	13
Swedish iron, not softened	55	Zinc*	12
Soft cast steel	41	Lead	10
Nickel*	34	German silver	7
Hardened cast steel	28	Mercury*	2
Cobalt*	24	Carbon*	1

* Being unable to procure wires of these metals, they were tested in the form of strips, and compared with similar strips of copper. Mercury was in a glass tube 2 mm. in diameter; carbon tested in the form of electric light carbon from 3 mm. to 10 mm.

The above table is only true for wires of 1 mm. diameter, as the effect depends on the size of the wire in relation to the nature of the metal. In soft Swedish iron a diminution in the electromotive force of the extra-currents takes place with each increase in its section, and this has been partially foreseen by Maxwell,* who said: "The electromotive force arising from the induction of the current on itself is different in different parts of the section of the wire, being in general a function of the distance from the axis of the wire as well as time." From this I expected that the increase of electromotive force by an increased section would not increase directly as its sectional increase; but I was not prepared to find, as my experiments prove, that after a certain maximum diameter of wire has been reached a marked decrease in electromotive force takes place with each further sectional increase, and that this maximum is variable with each metal.

The diagram shows a rapid rise of force in soft iron from an extremely fine wire of 0·10 mm. section to a maximum at 1 mm., from which point there is a slow but continued decrease of force with each increase in the size of the wire, until at the comparatively great diameter of wire of 10 mm. the force is but a fraction more than in the extremely fine wire. Hard Swedish iron has a less initial force in the fine wire, and does not arrive at its maximum until the wire has 3 mm. diameter, being then nearly of the same force as soft iron of the same diameter; the fall from this point is somewhat similar, but less than soft iron until at 8 and 10 mm.; soft and hard iron have absolutely the same values. A curious change of values at different diameters will be seen in copper and brass. Copper, having nearly double the initial force in fine wires, arrives at its maximum at 4 mm.; but brass creeps slowly up, passing copper at 5 mm., arriving at its maximum at 6 mm., and finally, in the large section 10 mm., it has more force than copper, their positions being completely reversed. I have been unable to obtain wires of different diameters of other metals; but zinc rods of 10 mm. gave a still higher rate than brass, whilst in small diameters its force was less. For non-magnetic metals it is probable that the greater the specific resistance of the metal the greater will be the diameter of the wire before the fall commences. Carbon is remarkably free from self-induction, and although there is a rise of force in rods of 3 mm. to 10 mm., it is so small as to be hardly measurable. German silver rises with comparative rapidity, indicating that with wires of 20 mm. its force would equal that of copper. Carbon therefore seems peculiarly adapted as a resistance when used in the variable period of electric currents.

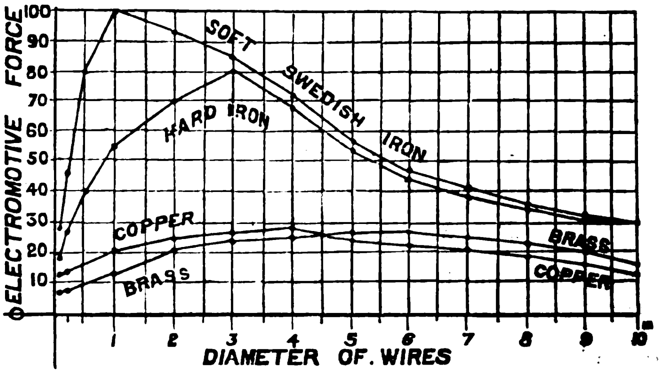

FIG. 2.

Influence of Parallel Currents.—The instrument being well adapted for showing the slightest change in the self-induction by the reaction of one portion of the current upon the other when in the same direction, as in a coil, or in the opposite direction, as in a parallel return wire, I made a series of experiments in order to observe the influence of different metallic conductors in this respect. Two silk-covered iron and copper wires of similar diameter and length (1 mm. diam., 2 metres in length) were each formed in a single loop of 66 cm. diameter. The extra currents from iron were, as usual, six times stronger than those from a similar loop of copper. On closing the loop by bringing the opposite sides in close proximity and thus making a parallel return wire (the current ascending on one side and descending the other), I found that the reaction of currents in opposite direction was very different with different metals, the results depending more upon the nature of the metal than upon the proximity of the wires. There was a reduction of the previous force of the extra currents in iron, when forming a parallel return wire, of 15 per cent., whilst the reduction in copper was 80 per cent. Thus the currents in copper are far more influenced by an external wire than those in iron; consequently a telephone line having its return wire in close proximity should invariably be of copper, as not only is its specific inductive capacity less, but this is again reduced by the return wire, so that its self-induction is far below that of iron.

In order to observe the influence of currents in the same direction, the same wires were formed into a close coil of twelve turns of 2 cm. diameter; and from the known effects of parallel currents in the same direction we should expect a greatly increased effect. It was so in the case of copper, but iron was far less under the influence of an external parallel current; the strength of current in iron when formed into a coil being 57 per cent. greater than that of a single wide loop, whilst in copper the increase was 404 per cent., or seven times the increase of iron; and although iron when in a single wide loop had six times the force of copper, the comparative strength was reversed when the wires were wound as a coil, the extra currents from the copper coil then having 14 per cent. greater strength than that from iron, and this difference could be rendered more evident by employing longer wires. Thus copper, as regards extra currents, is far more sensitive to the influence of external currents than iron, and the true self-induction from its own current can only be obtained by a straight wire, where the return wire is at such a distance that its influence is not appreciable.

Reaction of Contiguous Portions of the same Current.—It is well known that currents in separate portions of the same wire (as in a coil) react upon each other, and I felt convinced from the preceding experiment that self-induction is entirely due to similar electro-magnetic reactions between contiguous portions of the current in its own wire. Let us assume that an electric current consists of a bundle or an almost infinite number of parallel currents, the limit being a single line of consecutive molecules; then each line of current should by its electro-magnetic action react on each of the others similarly to wires conveying separate portions of the current, and the self-induction should be at its maximum when the lines are in the closest possible proximity, as in a conductor of circular section, and far less when separated, as in one of ribbon form, where the outlying portions are separated by a comparatively great distance. There would still remain, in the latter case, the reactions from the near portions on each other, and these should again be reduced by cutting the ribbon into a number of thin narrow strips, separated, except at their junction, to a sufficient distance to prevent any marked reaction.

My experiments prove that this assumption is an experimental fact, for we can reduce the self-induction of a current upon itself to a mere fraction

* "Electricity and Magnetism," Vol, II., p, 291.

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of its previous force by simply separating as indicated the contiguous portions of a current from each other, the results proving that a comparatively small separation, such as is obtained by employing ribbon conductors in place of a wire of the same weight, reduces the self-induction 80 per cent. in iron and 35 per cent. in copper; and if we still divide the current by cutting the ribbon into several, say 16, strips (separating the strips at least 1 cm. from each other), then the combined but separated strips show a still greater reduction, being 94 per cent. in iron and 75 per cent. in copper. The following table shows the comparative reduction of self-induction by employing ribbons and parallel separated wires:—

TABLE II.

Flat strips compared with round wire 30 cm. in length.	Copper.	Iron.	Parallel wires 30 cm. in length.	Copper.	Iron.
Wire 1 mm. diameter...	20	100	Wire 1 mm. diameter.	20	100
Strips. 0·25mm. thick, 2 mm. wide....................	15	35	Single wire. 0·25 mm. diameter ...	16	48
Same, 5 mm wide	13	20	Two similar wires ...	12	30
„ 10 „ „	11	15	Four „ „ ...	9	18
„ 20 „ „	10	14	Eight „ „ ...	8	10
„ 40 „ „	9	13	Sixteen „ „ ...	7	6
Same strip rolled up in the form of wire......	17	15	Same, 16 wires bound close together	18	12

The resistance of a conductor, or even the nature of its metal, has less influence on its self-induction than the form given to that conductor, the 1 mm. wire in the above table having a less resistance than the strip of 2 mm. wide, and a greater than any of the wider strips; but through all these variations we notice a gradual fall from the wire to the widest strip or ribbon, with a marked return to its previous force when the ribbon is rolled up in the form of a wire. The reduction is greater in iron than copper, but its increase when rolled up is less than copper, thus agreeing with the previous observations on the difference of iron and copper to external reactions. A still greater reduction takes place when we separate a current by using parallel wires separated 2 cm. from each other, as shown in the table. We then have a similar reduction to that produced by cutting the strips into several separate conductors; and we again remark that when the wires are brought close together (forming a stranded wire) copper rises in a far greater proportion than iron, the 16 fine iron wires twisted together as a stranded wire having 88 per cent. less induction than a solid wire of similar weight; a remarkable fact being that whilst a solid iron wire has an inductive capacity 80 per cent. greater than a sold copper wire, this is completely reversed when each metal forms a stranded wire of the same weight as the solid, for iron then has 33 per cent. less self-induction than copper. It is not necessary to use extremely fine wires when we desire to reduce the inductive capacity of iron to that of copper, for I have formed wire rope of 16 strands of wire where each wire was 1 mm. in diameter, giving 75 per cent. less induction than a solid wire of the same resistance. I purchased an ordinary wire rope of 6 mm. diameter, having 6 strands of 6 wires, each 0·5 mm. diameter; this gave the best result yet obtained, for, on comparing 3 metres of it with a similar length of solid iron wire of the same resistance, the 36-stranded wire had only 5 per cent. of the amount of induction shown by the solid wire. Steel, in the form of ribbon or stranded wires, shows a similar effect to that of iron; and it is a remarkable fact that, whilst the extra currents from a steel or iron wire 4 mm. in diameter are extremely slow, and impossible to balance without reducing the time of the sonometer current (by the introduction of an iron core), the ribbon or stranded wire requires no such compensation, for its feeble extra current is exceedingly sharp, and can be balanced to a perfect zero, being acually quicker than that of a solid wire of copper of the same resistance. This fact I regard as one of greater importance for telegraph lines and lightning conductors.

A curious effect takes place if we employ mixed conductors, such as a compound wire of copper and iron. A fine coating of copper reduces the induction in a solid iron wire in a marked degree. This I found to be due to the difference of electromotive force of the extra currents in the two metals, for, by employing a fine copper wire parallel with an iron wire, and in contact at the ends, the extra current was reduced 60 per cent. The copper wire, having a lower electromotive force, probably acts as a shunt; but if the capacity of the iron has already been reduced, as in a sheet or stranded wires, then the addition of a single copper strand increases the force, as the electromotive force of the extra-currents of copper is above that of stranded iron. There has been for many years a discussion as to the merits of the round form as compared with the tape or ribbon form for lightning conductors. Those in favour of the former based their conclusions on experiments which gave a negative or no apparent difference between the two forms of conductors. Those in favour of ribbon conductors, as Sir W. Snow Harris, Prof. Guillemin, and many others, based their opinion upon marked differences found when using high charges of static electricity. The latter supposed that there was a difference between discharges of static electricity and voltaic currents of low tension, and that the advantage recognised by almost conclusive experiments was due in a great measure to conduction by surface.

In the year 1864, Prof. Guillemin and myself, as members of the Commission de Perfectionment of the French Telegraph Administration, were charged with the mission of testing the comparative merits of the lightning protectors then used upon their lines. Our method of experimenting consisted in joining an insulated conductor to a short fine iron wire connected directly with the earth return wire. A Leyden jar battery charged by a Rhumkorff coil was discharged through this conductor, burning or deflagrating the fine iron wire. This wire represented the telegraph instrument requiring protection, and by placing the lightning protector connected with the earth in advance of the fine iron wire we could observe the amount of protection afforded. This answered extremely well for feeble discharges, but with the full power of our battery the fine iron wire was invariably destroyed, even with the best lightning protectors which are universally used to this day. Noticing that we could not give absolute protection to the fine wire by lightning protectors, we tried the effect of joining the conductor direct to a separate earth wire in advance of the fine wire, and with powerful discharges the wire beyond the protection was invariably burnt, notwithstanding that we connected the conductor direct to earth by a copper stranded wire of 1 cm. diameter. Prof. Guillemin continued these experiments after my departure for Russia, and he found, by employing a thin sheet of copper as a conductor to earth in place of the copper stranded wire placed in advance of the fine iron wire, that the wire could be perfectly protected. The theory of this action was not understood at the time, and the experiment has not received the attention it deserved; but the mutual reactions of contiguous currents shown in this paper explain the phenomenon in the fullest degree, for we see that a sheet or ribbon conductor has far less self-induction than a wire or rod of the same material.

I am fully convinced from the results of my experiments that an enormous retardation or resistance is evident in all conductors at the first portion of the variable period, and that this is due to self-induction, the current thus arousing an antagonist in its own path sufficiently powerful, when the primary current has a high electromotive force, to deflagrate or separate the wire into its constituent separate molecules, as shown by Dr. Warren de la Rue. It is also evident from my experiments—which are easily repeated, with invariable results—that a flat conductor has far less self-induction than a solid of circular section during the variable period; and even with a constant current, as in the stable period, this form of conductor, as first shown by Prof. George Forbes, would, from its greater radiation, convey more current with less heating than a wire or rod of the same resistance. Lightning conductors are intended to convey a current of high intensity during an exceedingly short time, and should therefore be designed so as to convey this current with as little opposition from self-induction as possible; consequently I regard a solid rod of iron as the worst possible form for a lightning conductor. The conductor, if of copper, should be of ribbon form, say 1 mm. by 10 cm. wide, or, if of iron, of numerous stranded wires or a wide ribbon of similar conductivity to that of the copper.

Self-Induction of a Telegraph Line.—A telegraph line may be considered as a single loop; the earth taking the place of a return wire can only affect the self-induction by a diminution of its effects, as in the case of a parallel return wire. Mr. W. H. Preece has lately read a most valuable paper on "The Relative Merits of Iron and Copper Wire for Telegraph Lines,"* in which he shows, by comparative rates of speed with the same instrument, that on a copper and an iron line of 278 miles in length (between London and Newcastle), whose resistance and static capacity were rendered equal, there was an increase of speed in the copper line of 12·9 per cent. as compared with an iron wire. I have not been able to test the relative speeds obtainable by telegraph instruments on wires of different material. The results in every case would depend very much on the apparatus employed, but I have considered the question from a point of view independent of the instruments. There is a remarkable difference in the resistance of a wire during the stable and the variable period, the measurements taken in the stable period giving no real or approximate idea of what its resistance really is during the rise of the current in the wire.

A curious fact in relation to telegraphy is that all measurements are made during the period of a constant flow of current, whilst all instruments—particularly those requiring rapid changes in the current—work only during the rise and fall of the current, as in the variable period. Telegraph engineers, however, have not made the mistake of assuming that there is no difference in the resistance of a wire in these two periods, as it is well known that electro-magnets and coils have a far higher resistance during the rise and fall of a current, and coils simply augment the effect of a straight wire of a given length. The present method of testing by Wheatstone bridge has been adopted because we had no practical means of measuring the resistance in the variable period; and I do not believe that this can be accomplished except by a similar method to that which I have used, in which the resistance and self-induction are separately measured and balanced, and by the use of an exceedingly rapid and sensitive instrument of observation as the telephone, in place of the sluggish galvanometers, no matter of what construction. The speed of telegraph instrements is greatly influenced by the resistance of the wire. I said in 1883† that a great difference would be found in the resistance of an electrical conductor if measured during the variable instead of the stable period, and I have made numerous experiments with the view of ascertaining to what extent this difference would probably be felt on telegraph lines. I have already mentioned that the time or the duration of the extra currents increases rapidly with the section of the conductor; consequently, comparisons can only be made between wires of similar section for speed, or wires of similar resistance for differences in their variable period. In measuring the resistance of a wire during the two periods, I have found it best to avoid the use of resistance coils, the simplest method being to measure or balance a given length of wire in one period, and then observing how much lengthening or shortening of the wire would produce a similar zero in the second

* British Association, Aberdeen, September, 1885.

† Discussion on the paper of W. H. Preece on Electrical Conductors, *Proc. Inst. Civil Engineers*, Vol. LXXV., 1883.

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period. Suppose that we commence by balancing the resistance during the variable period, and fix the sliding communications at the point at which we have obtained a perfect zero. We can now change to the stable period by means of the commutator; and as we no longer find a zero, but extremely loud sounds, we gradually lengthen the wire under observation until we have again a perfect zero. The amount of wire added to its previous length shows the difference in resistance between a conductor in which there are rapid electrical changes and that wherein the flow of current is constant.

Amongst numerous experiments I will cite a single example. I measured or balanced the resistance of an ordinary soft iron wire, 1 metre in length and 4 mm. diameter, during the variable period, and found that it required in the stable period exactly 2 metres 58 cm. to balance the previous resistance. Similar tests on a sample of best charcoal iron wire, as used on our telegraph lines, gave still more remarkable results, showing 225 per cent. difference between the two periods; for 1 metre of this wire had, during the rise and fall of the current, precisely the same resistance as 3 metres 25 cm. in the stable period. This shows that an iron telegraph wire has with rapid currents *more than three times* the resistance during its actual work than that supposed to be its true resistance. It was difficult on short lengths to find any change whatever in the resistance of copper or stranded iron wires in the two periods; the time of discharge being excessively rapid, I could only estimate the resistance by the electromotive force of the extra currents, or by forming the wires into coils (when a remarkably great difference is shown), and then estimating the proportional amount due to its own reaction; by this method I was enabled to detect 10 per cent. difference for a solid copper wire, and but 8 per cent. for the stranded rope of 36 iron wires. The difference in time of the duration of the extra currents between solid iron and copper and between solid iron and stranded iron is so great that we may consider a solid iron wire to belong, comparatively speaking, to the class of slow conductors, whilst copper and stranded iron would belong to the rapid.

I have shown a difference of resistance in the variable period between copper and iron of at least 200 per cent.—a difference which will be felt on instruments depending upon rapid changes, such as the telephone; and it is evident that the more rapid the contacts of a telegraph instrument the greater will be the difference between copper and iron. There is consequently a great electrical advantage in those instruments which require only a single current for each letter, as the economy of electrical impulses allows them to work at a comparatively high speed; the duration of the extra currents would be shorter than the length of their contacts, and consequently they would perceive very little, if any, difference between the two periods, or between iron and copper. If we use three or five currents for each letter, we must necessarily send them faster or closer together; and the difficulty increases in a rapid ratio with the speed of intermittent or reversed currents, until a point is reached (as I have shown in the case of best charcoal iron) where, whilst nominally working through 500 miles, we are practically working through an equivalent resistance of at least 1,500 miles, and this without taking into account the static charge, which would, in addition, from its comparatively extreme slowness of charge and discharge, cause the apparent resistance of the wire in the variable period to be much greater than I have mentioned. In Mr. Preece's experiments he finds a difference of speed of 12·9 per cent. between iron and copper, which is far less than the difference of resistance during the variable period which I have obtained; and this may be explained by assuming that the speed of the reversed currents which he employed was only near the border land of extra currents. I am convinced that if Mr. Preece could have increased the speed of the instruments he would have found a far greater difference between iron and copper; and if I regard the results of a solid iron wire alone, I should consider iron as unsuitable for telegraph instruments requiring extremely rapid currents. Copper would reign supreme if it were not for the fact, which I have discovered, that stranded iron wires have even a greater rapidity of action than copper.

Physical Changes in the Conductor.—Self-induction not only depends on the nature and form of its conductor, but also on the physical state of the metal, as already shown in the case of soft and hard iron. I felt convinced that the higher force in iron was due to its magnetic capacity, and to prove this I tried the effect of heating the wire to a bright red heat, or 1,000 deg. C. It is well known that iron loses its magnetic properties at bright red heat, and I found that its self-induction then fell to less than that of copper. This would have been conclusive had it not been for the fact that a different result takes place when the capacity of the iron for self-induction has already been reduced, as in the case of thin flat sheets of iron; in this case there is no disappearance or further decrease of induction except that due to the extra resistance caused by the increased temperature of the strip. Now, as the strip was highly magnetic when cold, and lost this property at red heat, there should have been some change in its self-induction if this were due to the magnetic nature of the iron alone. This requires further researches before a probable explanation can be given.

Iron is peculiarly sensitive to all physical changes. Mechanical strain of all kinds hardens the wire, and its influence on its self-induction can at once be detected. An iron wire under a moderate longitudinal strain loses 40 per cent., and its capacity is then less than unstrained cast steel. Iron well annealed has much less resistance than the same iron when hard drawn, and soft iron is generally employed for telegraph lines; but during the variable period a curious reversal takes place, as then soft iron has a higher resistance than hard iron. This apparent anomaly is easily explained if we compare the far higher self-induction of soft iron. Work is done at the expense of electrical energy, and the apparent higher resistance is due to the greater electro-magnetic action in soft iron. An iron wire shows traces of remaining circular magnetism after the passage of a continuous current, reducing the following extra currents 10 per cent.

Magnetising the wire, or subjecting it to mechanical vibrations, when used separately, produces no apparent change in its inductive capacity, but a remarkable change takes place if either of these is used in conjunction with a constant current. Let us pass a constant current and heat the wire to red heat, allowing it to cool with the current on; or, in place of heat, magnetise the wire; or, in place of magnetism, give the wire mechanical vibrations: the result of either of these being a strong internal circular magnetism, due, I believe, to the loosening of the magnetic molecules, allowing them to rotate with greater freedom under the influence of heat, mechanical vibrations, or magnetism. A wire thus treated has no longer its previous self-induction, which has fallen 60 per cent.; and as the circular magnetism becomes fixed when the vibrations cease, this molecular structure remains a constant as long as we employ intermittent currents in the same direction, but the structure disappears the instant a reverse current is sent; and this explains why we have more than double the amount of self-induction from reverse currents, as each reversal destroys any remaining magnetism due to the previous passage of the current. If we compare the electromotive force of self-induction on a given length of wire with the secondary currents generated in a second but independent circuit, we find that the self-induction is the most powerful, the secondary currents generated in a close independent copper wire being 20 per cent. less than its own wire. There is no difference between the self-induction of a current and the secondary currents; they are, in fact, as proved by Faraday, part of the same phenomenon. The self-induction is evidently due to the electro-magnetic reactions of the primacy current, and as magnetism permeates space, the separation of the wire only serves to insulate the primary, but does not affect its magnetic influence; and, as I have shown in the reactions of contiguous portions of the same current, so the magnetic reactions perpendicular to the axis of the current continue through the wire to all surrounding wires; and if we call the currents in the independent wire secondary, they are still secondary whilst enclosed in the wire of the primary; and as the reaction will ever be the strongest in the axis of the current, so will these currents be necessarily stronger than those induced in independent wires. For this reason we should be able to obtain extra currents of far higher electromotive force than would be possible from a secondary wire of the same length. It was my intention, on the reading of this paper, to demonstrate by practical experiments some remarkable properties of extra currents of high electromotive force; but I find that the subject and apparatus employed require a longer description than the limits of this paper allow. I must also leave aside for the present my experiments upon coils of different forms with cores of different metals. These, as well as other results obtained, indicate that there is a large field of useful research in many directions, each, however, requiring special studies according to the object we may have in view. The record of numerous experiments, of which this paper is only an abstract, shows that the nature of the metal as well as its physical condition has an important influence upon the self-induction of an electric current, and by a study of the reactions produced by the contiguous portions of a current, and by application of the results, we may, as in the case of iron, transform an extremely slow conductor into one of the greatest rapidity; I therefore hope not only that these researches may be of interest from a scientific point of view, but that the results obtained may be of practical utility in some of the numerous applications of electricity.

COMPANIES' MEETINGS & REPORTS.

The Cuba Submarine Telegraph Company (Limited).

The twenty-ninth ordinary general meeting of the shareholders of this Company was held at the Company's offices, 61, Old Broad-street, on Wednesday, 3rd February, under the presidency of Mr. Joaquin de Mancha.

The SECRETARY (Mr. James Scott) read the notice convening the meeting, and the Directors' report and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, the report enters so fully into all our doings during the last six months that I think it will require but few words from me on this occasion. You will see by the accounts that, after providing for the payment of the 1881 cable—the proportion that is due—and all other expenses, we have the sum of £8,641 for division. I think, taking into consideration the depression of trade all over the world, we must consider that the account is very satisfactory. Unfortunately we have suffered from that depression, for our business has somewhat declined. We have had about 500 fewer telegrams, as compared with the corresponding six months of last year, decreasing our income by about £1,000. Unfortunately last year, as we all know, the price of sugar was very much depressed, and as all the West Indies depend so much for their prosperity on that article, business men were therefore not so free in their communications, as the article they dealt in was at so low a price. But we hope that this year the crop will be very much better, and that our business will increase in consequence. There is one remark that I wish to make to you in reference to Paragraph 6 of the report, which says:—"The British Goverment having invited tenders for the laying and maintaining of a cable between Halifax (Nova Scotia), Bermuda, and Jamaica, with an Imperial subsidy, the Board has fully represented to the Government that the scheme, if carried out, would prejudicially affect the interests of this Company." When we first saw this advertisement we thought it desirable to communicate with all our friends connected with our line. After many consultations; and, in fact, having drawn out a scheme so that we might, if it was thought desirable, make an offer for laying this cable, we found that some of our colleagues would not enter

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into the matter. At one time it was thought that if they had all contributed towards the floating of a company, so as to be able to make an offer to the Government to lay down this cable, we might have to come before you to ask you as members of the Cuba Submarine Telegraph Company to take shares in this new company, but after due consideration we thought it was advisable not to offer at all. The difficulties connected with it are very great. From the report that the "Challenger" made to the Government it was found that the depth of the ocean was very great indeed—that in some cases the bottom was very rocky, and that we should have had in some parts to go down to a depth of four miles, so that in case of any accident it would have been almost impossible to get the cable up again. We thought, therefore, it would be advisable to have nothing to do with it. But we wrote to the Government to this effect, that if they should give a subsidy to some other company it might seriously injure us. The Government reply was as follows:—"Sir, with reference to the letter from this department of the 9th inst., I am directed by Secretary, Col. Stanley, to inform you that the Lords Commissioners of the Treasury have considered your representations respecting the proposed construction of a telegraph cable between Halifax, Bermuda, and Jamaica, and that Her Majesty's Government cannot depart from the decision which was arrived at on the ground of public policy to subsidise a cable between those points. Of course any tender in respect to the proposed new line of cable which your company may desire to make will be duly considered; together with other tenders in response to the advertisement, if sent by the 15th inst., as therein required." Well, gentlemen, after having received that reply we took no further action in the matter, except in endeavouring to ascertain whether other companies had offered for the laying down of this new cable. We have heard that there were two or three construction companies that made tenders, but we have not been able to ascertain upon what conditions, or whether the Government have accepted the tenders or not. Perhaps you would like to know the latest news we have on the subject. I wrote to the Government again, asking if they could inform us whether any offer had been accepted, or whether they had made any modification in their plans. To that we had no reply. Therefore, I expect that with the change of Administration and one thing or another they have not given their minds to it. We are consequently just as we were. We hope that the cable will not be laid. It would certainly prejudice us. But if it is laid we must do the best we can to make some arrangements by which this Company may not be seriously prejudiced. I think, gentlemen, that is all I have to say, except that, so far as our investments are concerned, you will see that following the desire of some of our members at one of our meetings we are reducing the amount that we have in some of the banks, so that it should not exceed £5,000 or so. But in these times of cheap money we have already had notices from some of the banks that were paying 5 per cent. that they will not be able to give us more than 4½ per cent. Therefore, for the present, we think it advisable not to move any farther. All the banks where our money is deposited are most reliable, and some of them, I think, compare favourably with any banks in the world, and we do not consider that it would be judicious to change from one bank to another, but to leave things as they are, so as to ensure as long as we can our gaining 5 per cent., which in these times is very difficult to do. With these observations, I will now move "That the report and accounts now submitted be received and adopted," and if any gentleman wishes to have any further explanation that I can give I shall be most happy to afford it.

Mr. A. F. Low: I beg to second that.

Mr. Greag congratulated the Board on having been able to keep the Company in so good a state as was revealed by the accounts. He threw out as a suggestion that it might be in the interests of the Company that the Board should devise some means whereby both preference and ordinary shareholders might sail in the same boat.

Mr. Goddard imagined that the securities in which their money was invested did not produce altogether 5 per cent., and he suggested whether the Directors should not be empowered by the shareholders to buy up the preference shares as they came into the market. They might thus effect some saving in the way of interest, and by some process gradually lead to the extinction of the preference shares.

Mr. Griffith congratulated the Directors on their past success, which he hoped in these perilous times would not desert them. He thought the Conservative Government were placing themselves in a wrong position when they came forward merely as the champions of the military, and entirely ignored the commercial interests involved in the question of laying the proposed cable. There could be no doubt that the Government had done wisely in deciding to lay an additional line to the West Coast of Africa, because there was a larger opening for trade there. The amount of time gained over the present system by laying that additional line would be inappreciable. Besides, in the event of war the cable would very likely be broken, and therefore unavailable. He was very glad to hear that the Board had determined to take no part in it. The depth of the ocean was so great in parts, that it would be almost impossible to grapple the cable and bring it to the surface again should it at any time come by an accident. He hoped Mr. Gladstone and his colleagues, who had greater respect for the interests of trade than the Conservatives, would not consider it necessary to sacrifice the shareholders for military reasons which were without foundation.

The Chairman said that the question of buying up the preference shares had engaged the attention of the Board, but it had been considered inexpedient to do so. The manager at Cuba had successfully repaired three or four defects in their cable at a very small outlay, without putting the Company to the expense of hiring and sending a steamer from England. The full expenses of that to the 31st of December had been about £500, and there would only be a few pounds more. He expressed the hope that under the Liberal Ministry it would not be considered necessary to proceed with the proposed new line between Halifax, Bermuda, and Jamaica.

The resolution was then carried unanimously.

The Chairman next proposed "that a dividend at the rate of 10 per cent. per annum free of income-tax on the preference shares, and 7 per cent. per annum free of income-tax on the ordinary shares, payable on and after to-morrow, be now declared."

Mr. Low seconded the resolution, which was agreed to.

On the motion of Mr. Goddard, a cordial vote of thanks was passed to the Chairman and Directors for their able conduct of the Company's business during the past six months.

The Chairman briefly replied, and the proceedings terminated.

The Maxim-Weston Electric Company (Limited).

An extraordinary general meeting of this Company was held on Monday at the Cannon street Hotel, Mr. Hugh Watt, M.P., in the chair, for the purpose of confirming the resolutions passed at a meeting of the Company held on the 15th ult.

Mr. John Wright (the Secretary), read the notice convening the meeting.

The Chairman said: Gentlemen, I do not know whether it is necessary for me on this occasion to repeat the arguments which I used when these resolutions were first placed before you as to the reasons which have induced the Board to arrive at the conclusion as to the desirability of reducing the amount—well, virtually reducing the amount—to the debit of patents account—that is, by reducing the capital of the Company to 5s. per share. I think, at least I hope, I made it clear to the shareholders on the last occasion that we considered ourselves, in view of existing circumstances, overweighted by an amount of capital which, as far as the present Board are concerned, never existed. In my humble opinion no patents at the present moment are equal to those in the possession of this Company, but in spite of that fact I do not think that it would be to the interests of the shareholders of this Company to reduce their capital to 5s. a share, which would reduce the patent account by something like £50,000. One reason which induced us to arrive at this conclusion was the existing state of the electrical market. We have not gone in connection with this company upon anything of an illusory character, and I hope we have viewed the position from a purely commercial point of view, and the Company has been conducted as far as we were able as a private enterprise. The result has been, in the opinion of the Directors, satisfactory so far, and we believe with the capital reduced as we propose, that we shall be able greatly to improve our position, and be able year after to present to the shareholders of this Company a more satisfactory condition of things than we have been able to do in preceding years. Another reason has been that in the opinion of our solicitors and counsel it would have been impossible for us for the past year to have declared a dividend. You were good enough at the end of last year to suggest in opposition to my recommendation the advisability of retaining the sum we proposed to pay in dividend, as working capital. On this occasion, I do not think we should ask the shareholders to show an equal degree of magnanimity—in fact, I think that now we ought to pay something. It is quite true that the present Board have not been in office since the floating of the original Electric Lighting Power Company, but the shareholders who, like myself, invested at a high premium, naturally want some return for their money, after some few years delay. I shall now propose, without further comment, the following resolution, and shall be glad to answer any questions put by any shareholders. I beg to propose that the following resolution be confirmed:—"That the capital of the Company be reduced by £62,500 by cancelling paid-up capital, unrepresented by available assets (being patents over-estimated in value) to the extent of 5s. per share upon each of the 250,000 shares which have been issued and are now outstanding."

The motion was seconded by Mr. Brown, and carried *nem. con.*

The Chairman then proposed for confirmation: "That the capital be further reduced by £62,500, by reducing the nominal amount of the remaining 250,000 shares of the Company's capital from 10s. to 5s. each, thereby leaving the nominal capital of the Company, £125,000, divided into 500,000 shares of 5s. each.

Mr. Lewis Swaby seconded the motion, which was carried unanimously.

The Chairman, referring to the financial position of the Company, said that the Board had deemed it advisable to pass the sum of £3,605. 5s. to a general reserve account, having been induced to do that from the fact that the late Board had left, among other legacies, a probable bad debt of £4,700. After allowing for the before-mentioned sum the balance remaining at the credit of the profit and loss account as at December 31st, 1885, was £5,285; and, seeing that the shareholders last year did not see fit to adopt the recommendation of the Board for the payment of a dividend, he was now willing to accept any suggestion for the distribution of a dividend.

Mr. Griffiths proposed the payment of a dividend of 7½ per cent. for the last year.

Mr. J. Barratt seconded the motion, which was carried unanimously.

The Chairman said the Directors would willingly carry out the wish of the meeting, and they would convene a general meeting within the next two weeks.

A vote of thanks was then passed to the Chairman for his services in connection with the resuscitation of the Company, and for his able administration of its affairs.

The Chairman, in acknowledging the compliment, said that he had received from influential sources promises of support of the Bill relating to amendments upon the existing Electric Lighting Acts, of which he gave notice on Thursday last, and he had reason to believe the Government would view his proposal very favourably.

The proceedings then terminated.

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Anglo American Brush Electric Light Corporation (Limited).

Report of the Directors to be submitted to the Shareholders at the fifth ordinary general meeting of the Corporation, at the Cannon-street Hotel, on Wednesday, the 10th inst., at 3 o'clock :—

The general prospects of the electric lighting industry have continued to improve, and although the advance has not been so great as was hoped for, the business and profits of the Corporation have sufficiently increased to justify, in the opinion of the Board, the distribution of a dividend. The range of the business of the Corporation has, during the past year, been largely extended. As a result of the absorption of the Great Western and Brush Midland Companies, reported on last year, important centres have been secured in South Wales and the West of England, and there is no reason to doubt that when the present legislative obstacles to central station lighting have been removed, the Corporation will benefit by the connections which have been established. An important station has also been acquired at Manchester, while a branch office has been opened at Edinburgh. The Continental work of the Corporation has again been of a very encouraging character, and the agency for the German Empire, organised about eighteen months back, especially promises further good results, the Corporation having lately entered into an arrangement for the establishment of a central lighting station in an important part of Berlin. In view of the magnitude and increasing importance of the foreign interests and relations of the Corporation, the Board have recognised the necessity of having a representative abroad, and they have appointed Mr. Frank Wynne, who for the last two years held the post of General Manager in England, to superintend the Continental work of the Corporation. The Corporation are able to show a satisfactory record of practical work done during the year. In addition to the share of Government contracts for the supply of electric lighting apparatus which the Corporation continue to receive, several profitable and interesting installations of the electric light have been carried out in docks, railway stations, collieries, factories, and private houses; also, as a somewhat new departure, a very successful installation has been completed upon the Duke of Bedford's yacht, "Northumbria," and upon others of a similar class. The International Inventions Exhibition afforded the Corporation a favourable opportunity of bringing to the notice of the public the merits of their numerous patents, the commercial and scientific value of which was recognised by the award of a gold medal. After referring to the fact that the Corporation are free from litigation, and their intention to enforce the legal recognition of their patent rights, the Directors refer with confidence to the early amendment of the Electric Lighting Act, and the introduction of the draft Bill prepared last year by the Electric Lighting Committee, which has been taken as the basis of a measure to be shortly submitted to the House of Lords by Lord Rayleigh.

The report continues: It will be seen from the balance-sheet that the called-up capital stands at £190,174. This is a diminution upon the figure at which capital stood last year of £795, due to the maximum number of shares to be issued to the members of the Great Western and Brush Midland Companies having been reduced by 159 shares in consequence of arrangements, advantageous to the Corporation, made with some of the shareholders of the Midland Company, by which they relinquished their claim to these shares in consideration of the liquidators accepting the difference only between the amounts of the call due by them and the value of the shares in the Corporation to which they would have become entitled upon paying the call in full. The total amount owing by the Corporation to creditors is £6,233. 17s. 2d., as against £3,726. 6s. 4d. in 1884, while the good debts due to the Corporation, together with cash at bankers, amount to £39,563. 1s. 2d., as against £30,102. 0s. 10d. last year, a comparison which will serve to indicate to some extent the improvement which has been effected in the financial position of the Corporation during the year. The patents and goodwill account has been increased by £12,536. 6s. 4d., about £11,000 of which represents the consideration paid in shares of the Corporation to the Great Western and Brush Midland Companies for the surrender of their licenses and the goodwill of their business. The reason for the amount of this consideration being larger than the estimate contained in the last annual report is that some of the other assets transferred by these companies to the Corporation have, in consequence of the reduced valuation of the plant and stores of the Corporation, been merged into the books at figures much below the original and otherwise perfectly justifiable estimates. The property account shows an increase upon last year's figure of £11,786. 8s. 10d., which is mainly due to the acquisition of the freehold and leasehold land and buildings and plant of the Great Western and Brush Midland Companies at Cardiff, Bristol, Cleethorpes, and other places, and to the purchase of the central generating station at Manchester, already referred to. The stock account, which stands at £69,626. 13s. 7d., shows no material alteration in the aggregate value of the stock on hand (taken at the valuation mentioned in the last annual report), stores, and goods in course of manufacture. The amount of £1,699. 11s. 6d. standing to the credit of assets realisation account represents the residue of the assets of the Great Western and Brush Midland Companies still to to be transferred to the Corporation by the liquidators. Should the assets still in the hands of the latter not realise this amount the deficiency will be added to the cost of the goodwill, &c., of these companies, in accordance with the principle laid down in the last annual report. The profit and loss account shows a gross profit of £20,935. 9s. 3d. after providing for bad and doubtful debts, and including the £500 received from the Anglo-Spanish Company mentioned in paragraph 11. After deducting all standing charges and expenses there remains a balance to credit of profit and loss account, including the balance of £1,627. 15s. 4d. brought forward from last year of £6,728. 6s. 8d. The standing charges, it will be noted, show an increase in the aggregate of £1,140. 17s. 2d. This is due partly to the higher premiums now generally demanded by fire insurance companies, to additional advertising, travelling, and to such other expenses as are directly attributable to the larger volume of business transacted by the Corporation during the year, and to the steps taken in furtherance of increased future developments. The Board recommend that £2,000 be applied to the reduction of properties and plant account, that £3,803. 9s. 7d. be applied to the payment of a dividend at the rate of 2 per cent. per annum on the whole share capital of the Corporation, and that the balance of £924. 17s. 1d. be carried forward to next account.

The report, in conclusion, says:—The Directors consider that there is good ground for encouragement in the prospects of business during the current year. The Corporation have already secured important contracts for lighting portions of the various Exhibitions to be held during the summer, and there is reason to hope that the negotiations which have been carried on during the past two years with the Corporation of the City of London for lighting an extended area are now approaching a satisfactory termination. The Board much regret to announce the loss to the Corporation of the services of two of the original Directors. Mr. Ladd, whose critical illness was referred to at the last meeting of the shareholders, died soon after, and later in the year Mr. Courtenay resigned his seat at the Board, owing to pressure of other engagements. The vacancies on the Board thus caused have been filled by the appointment of Lord Sudeley and Major-General Webber, R.E., C.B., and the shareholders will learn with satisfaction that the latter has been induced to accept the position of Managing Director. The Directors who retire this year are the Chairman, Lord Thurlow; the Vice-Chairman, Mr. Sellon; and Colonel Steuart, who, being eligible, offer themselves for re-election. Messrs. Cooper Brothers and Co., the auditors, also retire, and offer themselves for re-election. It is proposed that the dividend be payable on and after the 1st March.

THE KINETIC ENGINEERING COMPANY.—This company have opened a branch depot and show room at 117, Queen Victoria-street, E.C.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Feb. 3.		Business Done Week Ending Feb. 3. Highest.	Lowest.
Anglo-American	32,	33	32¼	—
Do. Preferred	54,	55	55½	54½
Do. Deferred	9,	10	9½	—
Brazilian Submarine	10¾,	11	10 15-16	10¾ xd.
Cuba	10½,	11	11 1-16	11
Do. Preference	17½,	18½	--	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9,	9½	9¼	9 1-16
Eastern Telegraph	11⅝,	11⅞	11⅞	11⅝
Do. 6 per Cent. Preference	13⅝,	13⅞	13⅞	13¾
Do. 5 per Cent. Debentures, 1899	104,	107	106	— xd.
Eastern Extension	12⅝,	12⅞	12⅞	12 11-16
German Union	9½,	10	—	— xd.
Globe Telegraph and Trust	6⅞,	7⅛	7 1-16	6⅞
Do. Preference	13⅝,	13⅞	13 11-16	13 9-16
Great Northern	14½,	15	14⅞	14⅝
Indo-European	33,	34	—	—
Reuter's	7,	7½	7¼	7
Submarine	205,	215	—	—
West India and Panama	⅝,	⅞	—	—
Do. 1st Preference	8,	8½	8½	--
Western Brazilian	6¼,	6¾	6⅜	6 5-16 xd.
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telepho e and Maintenance	15-16,	1 1-16	—	—
Oriental	3-16,	5-16	—	—
United Telephone	12,	12½	12½	12¼

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3,	3¼	3¼	3 1-16
Do (fully paid)	4¾,	5¼	5	—
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1½,	1¾	1⅝	—
Maxim-Weston	5-16,	7-16	—	—

MISCELLANEOUS.

Telegraph Construction	37,	38	38	37½
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24⅜	24¼

TRAFFIC RECEIPTS FOR JANUARY, 1886.

Companies.	Jan., 1886.	Jan., 1885.	Increase.	Decrease.
Cuba Submarine	2,850	3,013	—	163
Direct Spanish Telegraph	1,686	1,756	—	70
Eastern Extension	39,699	44,144	—	4,445
Eastern Telegraph	—	—	—	—
Great Northern	—	—	—	—
West Coast of America	—	—	—	—

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NOTES.

COREA.—The first telegraph line in Corea was opened on the 27th September.

SOCIETE BELGE D'ELECTRICIANS.—This society, which is now in its third year of existence, numbers 253 members.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—Gross earnings of this company for the month ending January 31st, 1886, £3,200.

THE POSTMASTER-GENERAL.—Lord Wolverton, the new Postmaster-General, has appointed Mr. F. A. R. Langton to be his private secretary.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 5th inst. amounted to £2,814.

PERSONAL.—Major R. L. Hippisley, Royal Engineers, has been appointed Instructor of Telegraphy in the School of Military Engineering, Chatham.

NEW ZEALAND.—Advices from New Zealand state that the cable steamer "Sherard Osborn" had left Wellington for Cook's Straits to repair the cable.

AN EXHIBITION OF LIGHTING APPARATUS.—It is stated that the Belgian Engineers' Association is preparing to hold next month an exhibition of all the various means of illumination hitherto used.

A CHANCE FOR ELECTRIC LIGHTING COMPANIES.—At the last meeting of the Northfleet Local Board the clerk was directed to issue advertisements inviting tenders for lighting the public streets of the district.

ELECTRIC RAILWAY.—Denver, U.S.A., is experimenting with an electric railway. Rails have been laid over a distance of about three miles. Prof. Short, of the Denver University, is the inventor and superintendent.

FIRE ALARMS.—The extensive premises of Messrs. Whiteley in Queen's-road and Westbourne-grove have been connected by means of the Exchange Telegraph Company's fire alarm with the fire station, Hermitage-street.

ATLANTIC CABLES.—Communication between Europe and America might have been entirely interrupted for many hours on the 29th ult. had it not been for the Mackay-Bennett direct New York cable *viâ* Coney Island.

APPOINTMENT.—We understand that Mr. William Fowler, Postal Telegraph Service, Aberdeen, has been appointed inspecting telegraphist for the north of Scotland. Mr. Fowler has been in the Aberdeen office for 15 years.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 5th inst. were £2,214, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—Subject to the audit, the directors of this company propose a dividend of 15 per cent. (£1. 16s. per share), in addition to the interim dividend of 5 per cent. already paid, making 20 per cent. for the year 1885.

NEW COMPANY.—It is reported that a company has been registered under the title of the Welsbach Incandescent Light Company (Limited), for the purpose of acquiring "the benefit of an invention of Dr. Carl Auer von Welsbach for incandescent lights." Capital £30,000, in £1 shares.

APROPOS OF THE ELECTRIC BOY.—*Apropos* of the electric boy, those of our readers who are interested in marvels should look up the account of the *Reduvius Serratus*, or West Indian Wheel-bug, in our issue of May 29th, 1880, and the description of the electric cow in our issue of July 10th, 1880.

ELECTRIC STORM SIGNALS.—If it be required to show storm signals during the night-time at the signal service station in Boston, U.S.A., the lanterns are lighted by electric lights, which make them remarkably brilliant. This is the only station in the country at which electric lights are used for the signals.

THE SENSOPHONE.—A modification of the sounder telegraphic instrument has been introduced in the United States. It is called the sensophone, and delivers signals by a series of light pricks, the finger being placed upon a button on the instrument. It is said to have found favour with operators.

THE ELECTRIC LIGHT FOR WARSHIPS.—The new French ironclad "Le Courbet" is to receive an installation of 350 incandescent lamps for the interior of the vessel, and 12 lights of 30 candle-power, and 2 powerful arcs for deck use. The work has been entrusted to Messrs. Sautter, Lemonnier, and Co.

THE ELECTRIC LIGHT FOR MILLS.—MM. Jamin and Leroux, of Mans, have ordered 100 incandescent lamps of Messrs. Sautter, Lemonnier, and Co. These, we understand, are for an experimental installation; if found satisfactory, the mill belonging to the firm will be lighted throughout by electricity.

THE ZIPERNOWSKY-DERI SYSTEM IN ROME.—An installation, including the use of 12,000 lamps, varying from 8 to 10 candle-power, is to be put down in Rome. The system employed is to be the Zipernowsky-Deri, and Messrs. Ganz and Co. have charge of the work. 1,500 lamps are to be in position by next May.

AN INTERESTING PAMPHLET.—We have been favoured with an exhaustive pamphlet by Mr. F. J. Sprague on the "Application of Electricity to Propulsion on Elevated Railroads." Pressure on our columns has prevented us hitherto from presenting this interesting paper to our readers. We shall, however, publish it at the first opportunity.

QUICK WORK.—One of the leading firms of arbitrage brokers in New York sent a message on the 28th ultimo from the Stock Exchange office of the Mackay-Bennett Cable Company to London. The business referred to in the message was transacted, and the answer received in New York in the space of *six minutes*, the quickest time on record.

THE TELEPHONE IN BELGIUM.—On the 24th inst. a concession for the establishment and working of a telephone system in the town of Termonde and its vicinity will be let by public contract at the Brussels Bourse. On the 3rd proximo a similar concession will be let for the town of Malines. The caution money in each case is fixed at £400.

LOCAL SOUNDERS IN AMERICA.—Our American namesake states that there are in daily use on the Morse telegraph lines of the United States not less than 30,000 local sounders. The total consumption of copper in the local batteries amounts to about 750,000lb. per annum, representing a sum of £6,300. Of zinc, 100,000lb. is used, equivalent to a value of £1,200. The total value is probably over £10,000 per annum.

SHREWSBURY.—At the last meeting of the Shrewsbury Town Council the town clerk stated that a communication had been received from the Post Office authorities to the effect that they should require £12 a year for supplying the electric clock, under a lease for five years. The wires would be supplied by the post office authorities, but the receiving appliances would have to be supplied by the Town Council. The consideration of the question was adjourned.

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SKATING BY THE ELECTRIC LIGHT.—During the skating season the large loch at Morriston Farm, Cambuslang, near Glasgow, was brilliantly lighted by means of three Crompton "D. D." arc lamps of 3,000 candle-power each, supplied by current from a Crompton-Bürgin machine. The loch was crowded each evening, and the scene is stated to have been picturesque in the extreme. The lighting was carried out by Messrs. Henry Bennett and Co., of Glasgow.

CITY AND GUILDS OF LONDON INSTITUTE.—As will be seen on reference to our advertisement columns, a course of 12 lectures, for engineering students and others, "On the Differential and Integral Calculus," will be given by Prof. Henrici, F.R.S., on Wednesdays, at 5 p.m., commencing on the 3rd prox. A course of six lectures, "On Some of the Industrial Applications of Electricity," will be given by Prof. Ayrton, F.R.S., on Friday, at 5 p.m., commencing on the 12th prox.

SWAN LAMPS IN GERMANY.—It is said that in the patent suit Swan *v.* Edison, the Swan Company has withdrawn its appeal before the Court at Leipzig, after the report of the referee, Justizrath Hambrock, had been communicated to the Court and the parties, so that the recognition of the Imperial Patent Office, which had been claimed by Edison for nearly two years, is now legal. The Swan Company is understood to declare that it will continue the pending civil proceedings in the Berlin Court.

WHERE IS IT?—Our contemporary the *Metropolitan* says that at a special meeting of the Blackwall Town Council it was decided not to proceed with the proposed Improvement Bill, by which, it may be remembered, the Corporation sought to create a reserve fund in connection with their gas undertaking, and to revise and extend their electric lighting powers. We should like to hear something more of the proceedings of this council. We were not aware that Blackwall had attained to the dignity of a town.

THE WAVERLEY STATION INSTALLATION.—Owing to a slight accident to the dynamo machine, the electric lights at the Waverley Station, Edinburgh, went out on the night of the 5th inst., and the old gas lamps had to be called into requisition. Further advices state that the accident to the dynamo turns out to be of a more serious nature than was at first supposed. Part of the machinery has had to be forwarded to London for repair, and it is now believed that the lighting cannot be restored in less than a week.

A CURIOUS STORM.—Not long ago a fearful dust storm passed over Redhill, in South Australia. A thunderstorm also threatened, but little rain fell, although but a few miles distant, in a north-easterly direction, a large quantity of rain filled up dams and replenished tanks. Thunder and ligntning were severe at the time. The lightning struck the Hummock Ranges, setting fire to the grass, destroying over 300 acres of good feed. Several hundred sheep which were grazing on the land at the time of the fire narrowly escaped being destroyed.

AN INTERESTING INSTALLATION.—There is an interesting installation at Greenock. It consists of two 100-light dynamos, driven by a turbine, which is in turn driven by the town water supply on its passage to the filters. There are twenty 20 candle-power Swan lamps in the streets, fitted in the ordinary gas lanterns, and 90 Swan lamps, of the same power, fitted in a neighbouring sugar refinery. The installation has now been working for nearly twelve months, and we are informed that all the lamps have exceeded the span of life generally accorded to them.

ZINC.—L. l'Hote, in *Comptes Rendus*, says: As to the inquiry if zinc free from any foreign metals decomposes water either on boiling or in presence of dilute sulphuric acid, experiment proves that such is not the case. Pure zinc heated with distilled water in a flask, so arranged as to receive the gases over mercury, gives off no hydrogen on prolonged boiling. Nor is it attacked by dilute sulphuric acid. The presence of iron in proportions of from 3 to 5 in 100,000 enables it to decompose water. Traces of arsenic and antimony have the same effect.

THE EDINBURGH EXHIBITION.—We are informed that Messrs. Andrews and Co. have been allotted the lighting of a large portion of the International Exhibition to be held in Edinburgh in the coming season. The space thus allotted will be lighted with thirty-four Andrews arc lamps, supplied with current from two dynamo machines. One powerful Andrews arc lamp will also be erected on a mast 80ft. high in the courtyard of Old Edinboro. The other lights will be distributed throughout the machinery and motion departments of the exhibition.

GAS AND ELECTRICITY.—It was stated on the 10th inst., at the meeting of the Anglo-American Brush Electric Light Company that a Bill would shortly be introduced into the House of Lords to place electric lighting on the same footing as gas, and to effect that two clauses of the Act of 1882 would have to be repealed. That would stimulate an industry to such an extent that it alone would prove most efficient as relief works for the unemployed. It was calculated that work would be provided in London alone for over three years for more than 10,000 men at an expenditure of over £6,000,000.

GAINSBOROUGH.—The installation at Marshall, Sons, and Co.'s, of Gainsborough, is a very complete one. Their machine is capable of driving 40 lamps of 15 amperes or 60 lamps of 10 amperes, in 12 parallels of five each. Messrs. Marshall have provided for four such machines, so that it will be possible for them to put up 240 arc lamps from four dynamos, with an E.M.F. considerably below 300 volts. On the American system of running a number of lamps in series, this might be accomplished by four or five large machines, but the E.M.F. would have been fatal to anyone accidentally touching the wires.

PROPOSED TELEPHONIC EXCHANGE IN DUNFERMLINE.—A meeting was recently held in St. Margaret's Lecture Hall, Dunfermline, for the purpose of considering the propriety of establishing a telephonic exchange for Dunfermline, to be connected with Glasgow, Dundee, Stirling, and other towns. Mr. A. R. Bennett, the general manager of the National Telephone Company, was present, and explained the nature of the proposal, and the success which had attended the telephonic system in other towns. The scheme was favourably received, and it was left with Mr. Bennett to arrange for securing the necessary number of subscribers.

ANOTHER BOY BATTERY.—An American contemporary states that Frank Burnett, aged 15, residing with his widowed mother at Youngstown, O., is said to have developed powers indicating that he is an animated electric battery. He is slightly built, and on his approach chairs and tables dance and heavy articles totter that his natural strength could not move. The lad is unable to explain his unnatural power, and has always enjoyed good health. The tests made thus far show the lad to be able to do more than he has claimed. It is probable that medical experts will be called in to ascertain whether this phenominal youth is a cell or a sell.

THE ELECTRIC LIGHT IN LUCERNE.—Messrs. Ganz and Co., of Budapest, are engaged in installing the central station at

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Lucerne on the Zipernowsky-Deri system. The station is established at Thorenberg ,where a waterfall of a force of 600 horse-power is utilised to drive two turbines. The installation comprises two alternative current machines making 250 revolutions per minute, and each one furnishing a current of 30 to 35 amperes with a difference of potential at the terminals of 1,800 volts. The two machines will supply current to 3,600 lamps of 10 candle-power, but only one machine will be used at first. The station is intended to supply various establishments in the vicinity.

THE TELEPHONE IN STOCKHOLM.—The telephone industry is making great headway in Stockholm. On the 15th of last January the *Stockholms Almanna Telefonaktiebolag* had 3,164 subscribers on its list, as against 2,335 on the 15th of January, 1885, and 865 on the 15th of January, 1884. During the past year, 4,772,760 messages were transmitted, of which 85,308 were during the hours of 10 p.m. and 8 a.m. The increase represents 100 per cent. The subscription amounts to about £7 per annum. Stockholm is telephonically connected with Södertelje, Monlbo, Trosa, Dolarö, Vaxholm, Rotebro, and Upsala, and other neighbouring villages. The greatest length of line is from Stockholm to Trosa, a distance of about fifty miles.

EDISON-SWAN LAMPS.—Speaking of Edison lamps Mr. Hartnell says, I have numbers of installations where after 1,500 and 2,000 hours' work but a very small number have given way, only a small percentage of what was originally put up. In one instance the lamps have run over 5,000 hours each. In another over 2,000 with a loss of not more than 15 per cent. In a third, the installation comprises some 70 lamps, and only 7 have actually burnt out after a run of nearly 2,000 hours. I could give innumerable instances where they have lasted considerably longer than what is usually calculated their nominal lifetime; but I need not add more than this, that they have come up to and even exceeded my expectations.

JUVENILE LECTURE.—A few evenings ago Mr. D. Lockhart, one of the clerks in the telegraph department at the Yarmouth Post Office, gave a lecture, entitled "An Evening with the Telegraph." To illustrate the subject, Morse's printer and sounder, Wheatstone's A B C, &c., and Daniell's batteries were used. Wires were led from one end of the room to the other, and messages were despatched and received, greatly to the amusement of the audience. Mr. Lockhart traced the development of electric telegraphy, and gave several very interesting facts connected with the sending of messages, the rapidity of transit abroad, the speed of deciphering and transcribing, the extent of wire now employed in the metropolis, and other statistics, all of which had a special interest.

FESTIVITIES.—The Leeds telegraphists held their annual *soirée* in commemoration of the transfer of the telegraphs to the Post Office, in the Albert Hall, Cookridge-street, on Thursday evening in last week. Mr. C. Holliday, day superintendent, presided, and was supported by Mr. J. C. Chambers and Mr. J. H. Naylor, superintending engineers. The whole proceedings passed off in a satisfactory manner.—The annual dinner of the telegraph clerks of the Eastern District, given by the Norwich telegraph staff, was recently held at the Shire Hall Tavern, Norwich, under the presidency of Mr. J. H. Ayers (superintendent of the Norwich staff), assisted by Mr. W. J. Power, of the engineering department, Norwich, the Colchester telegraph staff being represented by several delegates.

ELECTRIC LIGHT ON THE STAGE.—On the 18th and 25th ultimo, by permission of Mr. D'Oyly Carte, "Iolanthe" was played at the Vestry Hall, Anerley. In the last scene a capital effect was produced by the electric light. The fairy queen Iolanthe and three of the fairies had on their heads a light of two candle-power with a reflector behind the whole attached to a comb fastened in the hair. The sentry had a lamp of greater power on his busby. My Lord Chancellor, Lord Mountarat, Lord Tollsler, Strephon and Phyllis each wore a small hair filament lamp mounted in artificial flowers. Each actor carried a small accumulator capable of running the lamp two or three hours. The accumulators, lamps, &c., were supplied by Messrs. Woodhose and Rawson.

THE ELECTRIC LIGHT IN KIMBERLEY, SOUTH AFRICA.—At the annual meeting of the Kimberley Corporation the Mayor stated that a sum of £2,000 had been expended in the electric light department on additional plant and improvement of old plant, enabling the service to be extended by another 14 lamps and at very little extra cost for maintenance. Proposals had been made to light up the railway station by this department, but as yet no satisfactory reply had been received from Government on the subject. The system of private lighting on the incandescent principle had already been discussed by the Council, the adoption of which would no doubt prove a source of revenue. He further remarked that Kimberley is the only town in South Africa the streets of which are lit by electricity.

THE INTERNATIONAL ELECTRIC COMPANY.—It is notified in the London *Gazette* that a petition for the winding up of this company, subject to the supervision of Her Majesty's High Court of Justice, Chancery Division, was presented on the 3rd inst. by the International Electric Company (Limited), of No. 4, Copthall-buildings, and by Ernest Cooper, of 14, George-street, Mansion House, the liquidator of the said company; and that the said petition is directed to be heard before Mr. Justice Pearson to-morrow (Saturday), and any creditor or contributory of the company desirous to oppose the making of an order for the winding up of the company, should appear at the time of hearing for that purpose. A copy of the petition will be furnished to any creditor or contributory of the company requiring the same by Hollams, Son, and Coward, of Mincing-lane.

PURIFICATION OF SULPHURIC ACID. — Prof. Kupferschlaeger, in the *Bulletin de la Société Chimique de Paris*, says :—All chemists know that commercial sulphuric acid, prepared from iron pyrites, contains lead and calcium sulphates, nitrous and sulphurous vapours, arsenic acid, sometimes selenious acid, thallium sulphate, and hydrogen fluoride. For its purification he dilutes it with its own weight of water, then passes through it in excess a current of washed sulphurous acid, so as to bring the arsenic and nitric acids to a lower stage of oxidation, and to reduce selenious acid, if present. A current of hydrogen sulphide is then passed through it twice, with an interval, each time as long as it is absorbed. The vessel is then closed, and allowed to stand for some time at a moderate temperature, so that the lead and arsenic sulphides, selenium, &c., may subside. The sulphuric acid is then rectified in glass retorts, applying the heat so as to reach the upper portion only.

MINING EXPERIMENTS.—During the course of some experiments carried out recently at a North Staffordshire mine, for the purpose of demonstrating the efficiency of the water cartridge, a missed shot occurred which illustrated the value of electricity as a means of shot firing. In the case of an ordinary shot, with fuse missing fire, it is customary to withdraw the workmen from the place and not to resume until the next shift. With the use of electricity, however, the moment the wires are disconnected from the battery there is an absolute immunity from the danger of an unexpected explosion, and the shot may

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be visited immediately, as was done in this instance. At the conclusion of the experiments Mr. Wynne, Government inspector, said that he was quite satisfied with what he had seen, and was prepared to report to the Home Office that the cartridge possessed that element of safety which was claimed for it. Mr. Wynne also referred to the question of firing shots by electricity, and hoped to see the system generally adopted.

Street Lighting in America.—The city officials of Baltimore have been investigating anew the subject of lighting streets in order to understand why that city has to pay so much more than other municipalities in this respect. Under the contract made early last year, Baltimore's cost of maintaining street gas lamps was $36·94 for each lamp per annum, burning only on dark nights, and $46·19 if allowed to burn all night. In comparison the following figures are collected, showing the amounts paid in other cities:—

New York	$25·00	Rochester	$18·12
Boston	31·85	Richmond	44·00
Washington	22·00	Dayton	21·11
New Orleans	24·00	Jersey City	25·00
Burlington	25·00	Cleveland	17·50
Auburn	17·50	Baltimore	46·19

New York has 23,038 gas lamps and 617 electric lights; Philadelphia has 13,555 gas lamps; Boston, 9,781 gas lamps and 401 electric lights; and Baltimore, 5,191 gas lamps and 243 electric lights.

The Telephone in Inverness.—Twelve months have now passed since the Inverness Telephone Exchange was opened for business. The progress which has been made during the year, and the amount of business transacted through the medium of the telephone is remarkably good. Beginning with 46 subscribers on its list, the number at the close of the year has increased to 67—an increase of 21. The total number of messages which have been transmitted through the Exchange during the year reached the grand total of 64,525. As the average time taken to transmit each message was about three minutes, and as 300 words can easily be exchanged in that time, it is calculated that no fewer than 19,357,500 words have been exchanged between the subscribers during the year. The network of wires which now passes through the town is a very satisfactory proof of the utility of the telephone system. The manager, Mr. R. C. Bennett, deserves credit for the manner in which the Exchange has been conducted.

Electric Illumination in Operations upon the Palate.—Mr. H. Morgan writes to the *Lancet* as follows:—"On Thursday last, having promised to perform an operation for the closure of a cleft palate, I found myself embarrassed by a failing light. Unwilling to postpone the operation, I gladly availed myself of the suggestion of Mr. Weiss, who was present, to use the electric lamp which he had been demonstrating to the students. Accordingly, having removed the mirror from one of Semon and Vesey's apparatus for illuminating the larynx, and which is supplied by four Leclanché cells, Mr. Weiss held the lamp just inside the mouth, and, by the beautiful, steady, and distinct light thus afforded, I was able to see clearly, better than even by the brightest daylight, and the operation was quickly and satisfactorily concluded. To those who, like myself, have had to postpone such operations, to the distress of the patient and at personal inconvenience, I feel sure that this new adjuvant will prove the greatest boon. The smallness of the apparatus makes it free from any inconvenience, and the almost entire absence of heat renders it void of danger, while the clear brightness of a steady light renders every step in this delicate operation more facile even to practised hands."

Patents and the Civil Service.—The Postmaster-General has reissued Section 27 of the Patents Act, 1883, with an amended notification relating to officers of the Crown who desire to take out patents as follows:—Any officer desirous of applying for a patent should, in the first instance, memorialise the Postmaster-General for his consent to the application, and should hand the memorial to the head of his department for submission to the Secretary. The memorial must contain, or be accompanied by, a statement of the nature of the invention or improvement. The Postmaster-General will, on receiving such application, specify the conditions on which he will give his consent. One condition of such consent being given will be that in any settlement of the terms for use by, or for, the Government of any such invention or improvement, regard is to be had by the Postmaster-General to any facilities in working out and perfecting the invention or improvement which the inventor may have enjoyed by reason of his official position. All communications on the subject of any invention or improvement will be treated as strictly confidential. Any officer applying for a patent without the consent of the Postmaster-General will be liable to be dismissed from the service of the Post Office.

The Electric Light for Steamships.—Messrs. Andrews and Co. have just completed an installation on board Messrs. Geo. Smith and Son's ss. "City of Bombay. The steamer has been fitted with the single-wire system, and the result has proved entirely satisfactory. In the saloon, state rooms, and music rooms, as well as in the passages, there are altogether fifty lamps on silver-plated pendants and brackets; while on the deck there are five cargo lamps, each of 50 candle-power, and the mast and side lights are each of two 50 candle-power lamps; one of each of these is, however, spare. In the engine room circuit, including the boilers and shaft tunnels, there are twenty-four lamps. The current is generated by two Andrews dynamos, type A, each capable of supplying eighty lamps, there being 112 on the whole ship. The vessel is furnished with considerable surplus lighting power. The same firm have also just finished a complete installation on board the largest steamer of the fleet of the Bedouin Steamship Company, of Liverpool. The lights are dispersed throughout the whole of the ship, including 50 candle-power lamps in the masthead, stern, and side lights. The installation consists of about 100 glow lamps, and the electricity is supplied by one of Andrews's slow-speed dynamos, driven by a Tangye engine.

Book Notices.—"The Electric Light in Workshops," by Charles Lever (Broadheath, Atlantic Printing and Publishing Company). This is a little *brochure* treating principally of the application of the arc lamp to the lighting of large works. In conclusion Mr. Lever has a word or two to say on the subject of some of the failures which have taken place in some works where the electric light has been introduced. These he attributes in the main to electric light charlatans. These gentry he says "are totally ignorant of electrical laws, and have had no experience in electric lighting. But they know how to talk, and sometimes receive an order to put up a few lights in a works as a result of their eloquent appeals. Having obtained the order, they send some inexperienced person (who has, probably, been induced to pay them £100 'to learn the business') to superintend a band of labourers, who are sent to carry out the installation, which, when completed, generally turns out to be a failure. Usually these men act as agents for some worthless system of electric lighting, the so-called patents of which are owned by a bogus company; or they content themselves by offering the 'latest' cheap and trashy dynamo or arc lamp which makes

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its appearance. There is only one remedy against them, and that is to ask the contractor to guarantee his lights to be satisfactory. By this means a good and reliable plant can be purchased, for such plant, when put up by experienced men, is just as reliable as any other class of machinery." We quite agree with Mr. Lever.—"Electric Lighting in the United States," by Charles Lever (Altrincham: A. Ingham), as its title indicates, reviews the various systems of electric lighting in operation in America.

GRAPHICAL SIGNALLING.—The idea of graphical signalling recently described at the meeting of the Royal United Service Institution by Lieutenant Glen, of the Inns of Court Volunteers, and Colonel Melville, of the Engineers, to whom it had occurred independently, promises to be fruitful both of scientific interest and practical results. Its purport, in brief, is to make possible the communication of a diagram or drawing (including maps or sketch plans) whenever the despatch of messages by heliograph, flag-signalling, or any form of telegraphy is possible; and the essence of both Colonel Melville's and Mr. Glen's plans is the description of points by reference to co-ordinates, which is the method commonly used to fix places in the indices to an atlas. The problem is to make this method of reference available for signalling purposes. Colonel Melville's solution is the simpler; but Mr. Glen's has been more thoroughly worked out, and has two peculiar features of practical importance. The chances of error in transmission and the time occupied in signalling are reduced by devices for conveying the necessary information with a relatively small number of letter-signals. And by a still more ingenious device the points can be fixed on the diagram to any required degree of accuracy and the degree of accuracy changed in the course of the same message; so that a reconnaissance plan of country, for example, might be broadly sketched in and the details of buildings or fortifications more carefully given. The efficacy of the method has been proved by the severe test of transmitting portraits with no greater loss of fidelity than is commonly incident to reproduction by the usual printing processes. It is obvious that the message itself, as written down for transmission or by the receiver, is virtually a ciphered drawing, and might as such be useful even where communication by writing was practicable.

EARTH CURRENTS.—At the last meeting of the Royal Society of Edinburgh, a most interesting and suggestive paper on "Earth Currents on the Ben Nevis Observatory Telegraph Cable," by Mr. H. N. Dickson, was read by Prof. Chrystal:—"Disturbance of the telegraphic instruments at the Observatory by earth currents had frequently been observed, and the inference drawn from the disturbances was that the currents always existed, though with varying degrees of strength. Extending from about the middle of September till about the middle of October, 1885, a series of careful observations was made, with the view of determining, if possible, how far the disturbances were regular. By means of a galvanometer inserted in the telegraphic circuit, observations were taken every hour, and the results appeared to show that from midnight till four o'clock a.m. there was an earth current passing up the mountain, and reaching its first maximum about two a.m. This was followed by a slight return current down the line till about five o'clock, when a strong current up the line set in, which reached its maximum for the day at ten o'clock forenoon, and its minimum at one p.m. Subsequently the current increased pretty rapidly down the line again till three p.m., and became rather unsteady during the next five hours. Then an up-hill current steadily set in again, increasing till nine o'clock, and reaching its minimum at eleven p.m. While these observations were in progress the summit of Ben Nevis was almost continuously enveloped in storm and mist, whereby the results were, to some extent, necessarily affected. When the top of the mountain was clear it was observed that there was a strong current passing up the cable, the current being reversed when the opposite condition of things prevailed. The current was always found to be down the line during a fall of snow. In the opinion of Prof. Chrystal, these results opened up an interesting field in electrical science, which could only be thoroughly investigated by help from Government. One thing required would be to obtain possession of a land line to make experiments as to the effect of earth currents along the horizontals. M. Sang said that the results detailed in the paper materially affected the results of the determination of the earth's density by means of a plummet. The deviation of the plummet on which those results were based might be caused entirely, he thought, by the presence of the currents spoken of."

PROGRESS IN THE NORTH OF ENGLAND.—We understand that during the past year Mr. Wilson Hartnell, of Leeds, erected some twenty installations. Of these, eighteen were on the incandescent system. One of the largest plants put down is that at Wentworth Castle, which comprises upwards of 400 lamps. The plant, which is sufficient for 650 lamps, consists of two Crompton compound dynamos, driven from a countershaft by two of Marshall's horizontal engines, fitted with the Hartnell patent governors. The steam is supplied by two steel Cornish boilers. The castle is lighted from cellar to roof, including conservatory and other adjoining buildings, and it is considered to be one of the largest and most complete installations in the North of England. There are seven installations in corn mills, where the dynamos are required, for the most part, to run all night; hence great care is needed in fixing, and the work must necessarily be well done to insure thorough success. Four installations are in woollen mills, one in a large cotton daubling concern, one large arc installation at Marshall's, Gainsborough, and two in paper mills, besides three private houses. All the dynamos used are of the compound type, except in the case of Colonel Brooke, at Huddersfield, where a shunt-wound dynamo and accumulators are employed. In one case both arc and incandescent lamps are driven from one machine, on separate circuits, and the result has been extremely satisfactory. One of the paper mills mentioned has some 350 lamps in all, driven from one machine by a special engine. The works cover a very large area, several acres, and are lighted throughout by Swan lamps by the single dynamo, and their gas plant has been superseded entirely. At Messrs. Marshall, Sons, and Co. there are some thirty arc lamps of the Crompton-Crabb double differential type, with a current of from sixteen to twenty amperes each, driven from a compound-wound machine. In this installation a somewhat novel and very effective method is introduced, that is, of grouping the lamps in sets of five, so that any set of five may be turned off at pleasure without interfering with the remainder, and that at the same time the power absorbed shall diminish in the same proportion. On this system any number of arc lamps may be driven from a single dynamo without a dangerous amount of electromotive force on the one hand or undue cost for leads on the other. In this case it was most difficult to get the work done at times in the erecting shop, but since these lamps were put in work has been carried on at night the same as with daylight. In the corn mills the chief feature is the cleanliness and non-liability to explode, but in addition to this it has been proved abundantly that where the dynamos have proper attention the incandescent system is much cheaper than gas.

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COMMON MISTAKES IN ELECTRICITY AND MAGNETISM.

BY G. W. VON TUNZELMANN, B.SC.

II.—FRICTIONAL ELECTRICITY.

In a former paper (*Electrician*, Vol. XV., page 94) I called the attention of teachers and others to some of the mistakes most commonly made by beginners in the study of magnetism. In the present paper I shall note in the same way some frequently recurring misapprehensions and difficulties with regard to simple electrical phenomena.

First Ideas of Electricity.—It is most important that the student should not be introduced to any theory of electrification until he has a thorough grasp of the elementary experiments from which it is deduced that there are two distinct kinds of electrification, that the electrification of a body is a physical quantity capable of measurement, and that the two distinct kinds of electrification stand in the same relation to each other as positive and negative algebraical quantities. It should also be pointed out to him that the decision as to which kind of electrification should be considered positive is purely arbitrary, but that for convenience in comparing different results a choice has been made once for all, and is always adhered to, viz., that the electrification produced on glass by rubbing it with silk is to be called *positive*, and the electrification produced on resin or sealing wax by rubbing it with silk is to be called *negative*.

Insulation.—It should be noted that when we speak of such bodies as silk, glass, resin, &c., as being non-conductors of electricity, or insulators, we really mean that they only conduct electricity with extreme difficulty, so that, strictly speaking, they are *very bad conductors*, and not *non-conductors*; but, bearing this in mind, it is convenient to use the expressions. In the case of air and other gases, *either dry or moist*, at pressures not greatly exceeding that of the atmosphere, we have not been able to obtain any evidence of electricity passing through them by ordinary conduction, and therefore they may with perfect strictness be called non-conductors or insulators.

It is a very common mistake that the difficulty of maintaining the electrification of an electric machine or other apparatus in damp air is caused by damp air being a good conductor of electricity. The true explanation is, that when the apparatus is exposed to damp air a thin film of water is condensed on the exposed portions of the apparatus, including the insulating supports; and water, we know, is a good conductor of electricity.

A good experimental illustration of this is given by Maxwell. Let two insulated conductors be placed in close proximity, and first charge them similarly and afterwards dissimilarly, making the charges in the two cases equal, noting in each case the time which elapses before the electrification disappears. It will be found that the conductors will retain their electrification longer when dissimilarly charged, because the electromotive force through the supports is less in this case, while when they are similarly charged the electromotive force is less through the air between them and greater through the supports.

Distribution of Electricity in Equilibrium.—It is shown experimentally that if a charged conductor be placed inside, and in contact with a closed hollow conductor, it will give up the *whole* of its charge to the conductor which encloses it, provided there are no electrified bodies within the hollow conductor, which are separated from it by an insulating medium.

From this experiment it can be shown mathematically that the law of electrical repulsion must be that of the inverse square of the distance.

The statement that "the electricity of a charged conductor, when it has attained its final distribution, is entirely upon the surface of the conductor" should, therefore, be simply presented to the student as a direct inference from the above experiment, and the teacher should guard against attempting to give a vague explanation that it is due to the self-repelling character of electricity. Such an explanation sounds plausible, but it is entirely misleading, for the result would not be obtained if the law of repulsion were other than that of the inverse square.

Dispersion of Electricity by Points.—Every learner knows as an experimental fact that electricity escapes more readily from a pointed portion of a conductor than from a rounded portion, but I have noticed that a large proportion are unable to give any reasonable explanation of it.

Now, the fact that the electric charge is found entirely on the surface of a conductor shows that at every point of the electrified conductor there is a force, due to the electrification of the rest of the conductor, acting outwards upon the electricity at that point, and it is clear that this force is perpendicular to the surface of the conductor, for otherwise it would have a component along the surface, and this component would cause a flow of electricity within the conductor.

Again, if an insulated charged conductor, rounded at one end and pointed at the other, be tested by means of the proof plane, a greater charge is obtained near the pointed end than near the rounded end, showing that a small portion of the surface near the pointed end carries a larger charge than an equal small portion near the rounded end.

Now, the *electric density* is defined as the charge on an indefinitely small portion of the surface divided by the area of that small portion. This experiment, therefore, shows that the electric density is greatest where the conductor is most pointed. But this accumulation of electricity is caused by the repulsive force exerted by the electricity distributed over the remaining portion of the conductor, and therefore we see that the repulsion acting on a unit quantity of electricity must be greatest at the most pointed end. Since the charge per unit of area is greatest when the conductor is most pointed, and the repulsion on each unit of electricity is greatest at the same place, it follows *a fortiori* that the force acting outward per unit of area of the surface or the *electric tension* is greatest at the pointed end. By increasing the sharpness of the pointed end the electric tension may be increased, until it becomes sufficient to break down the resistance of the insulating medium, allowing the electricity to escape.

Electrical Induction.—A very large proportion of the misapprehensions of learners arise from their not having properly understood the experiments shown them to illustrate *electrical induction*, which may be defined as the movement of electricity in a conductor, caused by external electricity.

They should be made to understand that when a light body such as a pith ball is attracted to an electrified body held near it, it is because it is first electrified by induction. It should be pointed out to them that if the pith ball be lying on a conductor it will become oppositely electrified to the inducing body, while if it be insulated it will become oppositely electrified on the side nearer to the inducing body, and similarly electrified on the further side, but that the opposite charge being nearer to the inducing body than the equal similar charge on the further side, the attraction will be greater than the repulsion, and the resultant of these two oppositely directed forces will therefore again be an attraction, but weaker than in the former case.

Action of Lightning Conductors.—The student should have it fully explained to him that the object of placing lightning conductors near buildings, or attaching them to the masts of ships, is not primarily to make the lightning strike them rather than the objects to be protected, but by allowing a free flow of electricity from the earth or sea by means of the pointed extremity, to prevent the earth or sea in the neighbourhood from becoming strongly electrified by the induction of the electrified clouds above, for if this be prevented no lightning discharge can take place. If, however, the conductor is unable to discharge the electricity of the earth with sufficient rapidity to prevent the passage of lightning from the cloud, the lightning will strike the conductor rather than the building, which is the same thing as saying that if a disruptive discharge does take place it will be from the extremity of the conductor rather than from any neighbouring point, because that is where the electric tension is greatest.

The student should be impressed with the importance of the earth connection being good, and should understand that a lightning conductor with a bad earth connection is useless.

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The Leyden Jar.—The theory of the Leyden Jar presents no difficulty when the principles of electric induction are properly understood, but beginners show a great tendency to ignore the fact that its action is entirely due to induction, and they often seem to imagine that electricity can be poured into the jar much as water is poured into a bottle.

To obviate this, the teacher should be careful that the student fully understands electrical induction before any attempt is made to explain the action of the jar, and as an additional safeguard against his attributing any magical influence to the jar form, I think it preferable first to make him familiar with the action of a condenser in some other form, such, for example, as two sheets of tinfoil pasted on opposite sides of a thick sheet of glass. It can then be explained to him that the condenser is commonly made in the form of a jar, because, for many purposes for which condensers are required, it is the most convenient shape.

It is also as well to point out that the jar is really complete as a condenser when the two coatings of tinfoil have been applied, and that the metallic ball in electrical communication with the inside coating, with which the jar is usually provided, is simply an extension of the inside coating, as a matter of convenience, to afford a ready means of approaching it to other electrical apparatus.

CORRESPONDENCE.

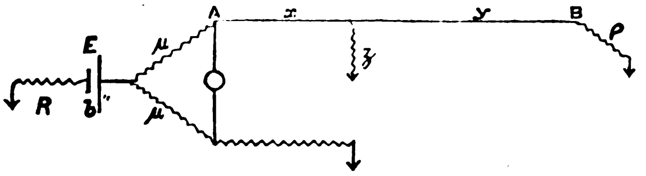
FORMULÆ FOR MAINTAINING THE CONSTANCY OF TESTING CURRENTS THROUGH A FAULT IN BLAVIER LOCALISATION MEASUREMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having read with interest Mr. H. Kingsford's paper on "Localising a Cable Fault by Tests from One End Only," as it appeared in *The Electrician* of the 18th inst., I have ventured to draw up from it and from the general literature of the subject—notably the late Mr. Schwendler's work on testing—a set of formulæ which will, I trust, form a concise and useful reference for such of your readers as are practically interested in fault localisation.

Even when every care is taken with the measurements of a Blavier test, and every efficient correction has been introduced, electricians prefer, I think, to place more reliance upon some method of localisation dependent on simultaneous observations from both ends of the cable, such as "potential" tests, "overlap" tests and the like; but since such co-operation from the distant end cannot in all cases be obtained, and since without such co-operation the Blavier method is, so far as we know, the only one by which the measurement of resistances at one end alone indicates the distance of the fault, it is of considerable importance to raise as far as possible the standard of accuracy in the Blavier method, and we owe, I think, to Mr. Kingsford a convenient means of eliminating its principal source of error—the variation of the fault's resistance with the change of current passing through it in the different measurements.

As it sometimes happens, especially in cable repairing, that the normal conductor resistance of the cable between the ends is not accurately known, we shall introduce formulæ to deal with such cases, as well as the simple condition when the normal conductor resistance is given.



Let A B be a cable of conductor resistance $(x+y)$, and with one fault of resistance z, situated at distances of x and y ohms from A and B respectively. Suppose that A only can measure resistances by a Wheatstone bridge, as shown, where $\mu\,\mu$ are the equal arms; also a battery of electromotive force E and internal resistance b with an adjustable resistance R in the earth wire.

B cannot take measurements, but can alter the electrical condition of his end by the interposition of a known variable resistance ρ between it and earth. To free the cable, this resistance is made infinity; to put the cable to earth, it is made zero, while between those limits any convenient concerted value, ρ, can be brought in circuit.

Let us also assume that A takes all measurements to "false" or earth-current zero, and that the resistance z of the fault is constant for a constant testing current traversing it.

Then, since the variation of ρ at B must alter, other things being equal, the current strength in z, it will be necessary to maintain that strength uniform that a corresponding inverse change be produced in the strength of the outgoing testing current at A. This can be done in three ways:—

1st. By varying the electromotive force E.

2nd. By introducing a variable resistance into the circuit.

3rd. By establishing a variable derived circuit at some point in the system to carry off the superfluous current from the line.

Of these three methods we shall only examine the first two, as the third is the most complicated and the least advantageous.

To maintain a constant current in the fault by varying the testing electromotive force.

This corresponds to the case of a single Wheatstone bridge at station A, and a battery of a variable number of cells with no available rheostat, R.

We shall consider the cases—

1st. When the normal conductor resistance $(x+y)$ is unknown.

2nd. When $(x+y)=l$ a known quantity. At present we suppose that in the figure $R=0$.

1st. Let B during arranged intervals free his end $(\rho=\infty)$, then introduce a specified resistance to earth, ρ, and then earth direct $(\rho=0)$.

Let f, r, and e be the first set of measurements taken at A (with the same battery), corresponding to those conditions at B respectively. Then from Schwendler's equations the first preliminary values of x, y, and z have to be found as follows—

$$x=f-\sqrt{\frac{(f-r)\,(f-e)\,\rho}{r-e}} \quad . \quad . \quad . \quad (1)$$

$$y=\rho\left(\frac{f-r}{r-e}\right)-z \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$z=f-x. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Now fix upon a suitable number of cells to employ in the measurement of r, and let N_r be that number. Then the correct numbers of the cells to be used in observing f and e, while maintaining a uniform testing current in the fault will be—

$$N_f=N_r+\frac{k}{k+z\,(\mu+x)+2\,z\,N_r\,b} \quad . \quad . \quad . \quad (4)$$

and

$$N_e=N_r+\frac{k+\frac{z}{y}\,(\mu+x)\,(y+\rho)}{k+z\,(\mu+x)-2\,\frac{z\rho}{y}N_r\,b} \quad . \quad . \quad . \quad (5)$$

where b is the resistance of each cell, and $k=(y+\rho)\,(\mu+x+z)$.

When Minotto cells are employed, or when the resistances of $\mu\;x\;y$ and z are not relatively large to the internal resistance of the batteries, these formulæ may have to be employed; but in most cases, with a suitable battery, its internal resistance may be neglected, and the equations then become:

$$N_f=N_r\times\frac{k}{k+z\,(\mu+x)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

$$N_e=N_r\times\frac{k+\frac{z}{y}\,(\mu+x)\,(y+\rho)}{k+z\,(\mu+x)} \quad . \quad . \quad . \quad (7)$$

where $k=(y+\rho)\,(\mu+x+z)$

As these equations seldom yield whole numbers, the nearest integer has to be accepted.

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A second set of f r and e has now to be taken with the batteries of N_f N_r and N_e cells respectively, and the readings so obtained may be denoted by f_1, r_1, and e_1.

Substituting these values in equations (1), (2), and (3), the first approximation to the true values of x, y, and z will be obtained, namely, x_1 y_1 and z_1, which by the use of equations (4) and (5), or (6) and (7), will supply new values of N_f and N_e to be employed in measuring f_2 r_2 and e_2.

This process of approximation has to be carried on until two consecutive sets f r and e are alike. These sets should then supply the true values of x, y, and z.

If, as has been assumed, the resistance of the fault is steady under a constant testing current, in most cases the second approximation will be sufficient to fix x, y, and z, with all the accuracy that the conditions of the test supply—in other words, the calculation will cease at f_3, r_3, and e_3.

But if, as frequently happens, the resistance of the fault is not steady under a constant testing current, then the equality of f_n, r_n, and e_n with f_{n-1}, r_{n-1}, and e_{n-1} cannot be expected, however great n may be; but a mean value of each is to be hoped for which will probably supply results for x, y, and z nearer to the truth than if no approximation had been attempted.

It is evident from equation (1) that the best value to give ρ is generally such as will make r approximate to $\frac{f+e}{2}$.

We may illustrate the case by an example. Suppose that A with the same battery power took the preliminary measurements of f, r, and e, as follows :—

$$f=1200\omega, \quad r=955\cdot0\omega, \quad e=760\omega; \quad \text{while } \rho \text{ was } 1000\omega.$$

From these values and equations (1), (2), and (3), the first results are

$$x=456\cdot5\omega, \quad y=513\omega, \quad z=743\cdot5\omega.$$

Next suppose that A had a number of cells each of one volt E.M.F. and ten ohms internal resistance, and that he selected twenty for the measurement of r, also that the arms of his bridge were 1000ω each.

Then by formulæ (6) and (7)

$$N_f=14\cdot193, \text{ and } N_e=31\cdot698.$$

A would then repeat the measurement of f r and e with 14, 20 and 32 cells respectively.

Suppose that the readings he then obtained were

$$f_1=1200\omega, \quad r_1=933\omega, \quad e_1=743\omega.$$

By equations (1) (2) and (3) as before, these values give

$$x_1=398\cdot6\omega, \quad y_1=603\cdot6\omega, \quad z=801\cdot4\omega.$$

Substituting again in equations (6) and (7)

$$N_f=15\cdot18, \text{ and } N_e=27\cdot99.$$

Repeating the measurements with 15, 20, and 28 cells suppose A found

$$f_2=1200\omega, \quad r_2=933\cdot3\omega, \quad e_2=742\cdot9\omega.$$

These figures, substituted in equations (1), (2), and (3), give

$$x_2=400\omega, \quad y_2=600\omega, \quad z_2=800\omega.$$

And those again in equations (4) and (5) give

$$N_f=14\cdot193, \text{ and } N_e=31\cdot698.$$

Repetition of f, r, and e, with 14, 20, and 32 cells, may be supposed to have given

$$f_3=1200\omega=f_2, \quad r_3=933\cdot3\omega=r_2, \quad e_3=742\cdot9\omega=e_3.$$

So that x_2, y_2 and z_2 would be the final results, and the testing current through the fault in measuring f_3, r_3, and e_3 would be approximately 5·7 milliamperes in each case.

Practically we could seldom expect to arrive at the true values of x, y, and z so closely as we have traced them in the above example; but we should certainly expect to arrive at more accurate results than if we employed the same battery power for all measurements.

2nd. When $x+y=l$ a known quantity. B need in this case free and earth only, and A will first observe preliminary values of f and e with the same battery power.

These will supply the first results for x, y, and z by the ordinary formulæ

$$x=e-\sqrt{(f-e)\ (l-e)} \quad \ldots\ldots \quad (8)$$

$$y=l-x \quad \ldots\ldots\ldots\ldots \quad (9)$$

$$z=f-x \quad \ldots\ldots\ldots\ldots \quad (10)$$

A suitable number of cells has then to be selected for measuring f or e. Suppose we take a certain number, N_f, for the observation of f, then

$$N_e=N_f\times\frac{p+\frac{z}{y}(\mu+x)}{p-2N_f b\frac{z}{y}} \quad \ldots\ldots \quad (11)$$

where $\quad p=\mu+x+z$

and when the resistance of the battery is low relatively to the other values, and may be neglected, then

$$N_e=N_f\times\frac{p+\frac{z}{y}(\mu+x)}{p} \quad \ldots\ldots \quad (12)$$

b is the resistance of a single cell, as before.

A now repeats the measurement of f and e with N_f and N_e^1 cells respectively, observing values f_1 and e_1, which by equations (8), (9), and (10) will give more approximate results for x, y, and z, namely, x_1, y_1, and z_1. And, as in the first case, the approximation is continued until f_n and e_n are the same as f_{n-1} and e_{n-1}, when both sets should yield correct results for x, y, and z.

We may illustrate this case by another example. Suppose that with the same battery A finds

$$f=1050\omega, \quad e=840\omega, \quad \text{when } l=1000\omega.$$

Then by equations (8), (9), and (10) these make

$$x=657\omega, \quad y=343\omega, \quad z=393\omega.$$

Now, suppose A selects 10 cells of 10 ohms each, to employ in observing f, while the ratio of his bridge remains at $1000\omega : 1000\omega$, then by equation (12) the above values of x, y, and z give

$$N_e=19\cdot263.$$

A then observes f_1 and e_1 with 10 and 19 cells respectively, and, say, he finds

$$f_1=1080\omega, \quad \text{and } e_1=831\cdot5\omega.$$

These figures give by equations (8), (9), and (10)

$$x_1=626\cdot4\omega, \quad y_1=373\cdot6\omega, \quad z_1=453\cdot6\omega.$$

Substituting those again in formula (11),

$$N_e=22\cdot06.$$

A now observes f_2 and e_2 with 10 and 22 cells.

Suppose that he then finds

$$f_2=1100\omega, \quad e_2=822\cdot2\omega.$$

From these and equations (8), (9), and (10)

$$x_2=600\omega, \quad y_2=400\omega, \quad z_2=500\omega.$$

Substituting in equation (11)

$$N_e=22\cdot162$$

Repeating f and e with 10 and 22 cells, A would probably find

$$f_3=1100\omega=f_2, \quad e_3=822\cdot2\omega=e_2$$

and x_2 y_2 and z_2 would be the accepted results. Also if each cell had an electromotive force of one volt the current flowing through the fault would be approximately 4·3 milliamperes in observing both f_3 and e_3.

To maintain the current in the fault constant by the introduction of a variable resistance into the circuit.

The variable resistance has to be introduced at A either between the bridge and cable, or between the bridge and earth. If in the former position, the amount of compensating resistance introduced must always be twice the amount necessary if introduced in the latter position (when the ratio of the bridge arms is unity). For instance, 2000ω between the cable and bridge has the same effect as 1000ω in the earth wire, so that the figure shows the simpler fundamental con-

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ception, and all values that we shall find for R will correspond to 2 R added to the cable, if that position for the rheostat is preferred.

1st. When the normal conductor resistance $(x+y)$ is unknown.

B frees, earths through a resistance ρ, and then earths direct, just as in the first case considered, while with the same battery and R either zero or constant, A observes the preliminary values of f, r, and e.

By equations (1), (2), and (3) these will supply the first values of x, y, and z.

A now selects a suitable battery-power with which to observe e while $R=0$. Then the values R_f and R_r to be given to R, so that in all three measurements the testing current through the fault may be constant, are

$$R_f = \frac{z\,(2\,b+\mu+x)}{2\,y} \quad \ldots\ldots \quad (13)$$

$$R_r = \frac{z\,\rho\,(2\,b+\mu+x)}{2\,y\,(y+\,.\,z+\rho)} \quad \ldots\ldots \quad (14)$$

so that

$$R_f = R_r\left(\frac{y+z+\rho}{\rho}\right) \quad \ldots\ldots \quad (15)$$

where b is now the internal resistance of the whole battery.

A now repeats the measurement of f, r, and e, making $R=R_f$, $R=R_r$, and $R=0$ respectively. Let f_1, r_1, and e_1 be the measurements so obtained. By equations (1), (2), and (3) these give x_1, y_1, and z_1, and these again supply more approximate values of R_f and R_r. Proceeding in this way, if the fault's resistance is constant for a constant current, we may expect to find a set f_n, r_n, and e_n, equal to f_{n-1}, r_{n-1}, and e_{n-1}, when x_{n-1}, y_{n-1}, and z_{n-1} will be the final results.

We may illustrate the case by an example. Suppose that with $R=0$, and one battery A finds the preliminary values of f, r, and e as follows :—

$$f=1500\omega,\quad r=1134\omega,\quad e=853\omega,\quad \text{while } \rho=1000\omega.$$

By equations (1), (2), and (3),

$$x=582\omega,\quad y=384{\cdot}5\omega,\quad z=918\omega.$$

By equations (13) and (14),

$$R_f=2127\omega,\quad R_r=924\omega,$$

A now selects a battery for the measurement of e, with an internal resistance of 100ω, when $R=0$, and then repeats f, r, and e with R_f and R_r. Suppose he obtains

$$f_1=1500\omega,\quad r_1=1115\omega,\quad e_1=844\omega.$$

From these, by equations (1), (2), and (3),

$$x_1=534{\cdot}6\omega,\quad y_1=455{\cdot}3\omega,\quad z_1=965{\cdot}4\omega.$$

By equations (13) and (14),

$$R_f=1839\omega,\quad R_r=760\omega.$$

Introducing these resistances, A repeats f, r, and e, and finds, say,

$$f_2=1500\omega,\quad r_2=1100\omega,\quad e_2=833{\cdot}3\omega.$$

By equations (1), (2), and (3),

$$x_2=500\omega,\quad y_2=500\omega,\quad z_2=1000\omega.$$

And by equations (13) and (14)

$$R_f=1700\omega,\quad R_r=680.$$

We may now suppose that A, on repeating f, r, and e, finds

$$f_3=1500\omega=f_2,\quad r_3=1100\omega=r_2,\quad e_3=833{\cdot}3\omega=e_2.$$

Then x_2, y_2, and z_2 would be the accepted values, and with an electromotive force of twenty volts in the testing battery the testing current through the fault would be approximately 3·28 milliamperes in each observation of the last set.

2nd. When the normal conductor resistance $(x+y)=l$, a known quantity.

B frees and earths direct, while with one battery and R constant or zero, A measures the preliminary values of f and e. From these and equations (8), (9), and (10), the first values of x, y, and z are found. A then selects a battery of internal resistance b, for the measurement of e with $R=0$, and then the value of R to insert when measuring f is given in equation (13). New readings, f_1 and e_1, are then taken, and new values, x_1, y_1, and z_1, found. As before, approximation has to continue until f_n and e_n equal f_{n-1} and e_{n-1} respectively, when x_{n-1}, y_{n-1}, and z_{n-1} are the final results. If the fault's resistance is not constant for a constant traversing current, then, as we have already remarked, this equality cannot be expected, and a mean value only of all the quantities involved is to be hoped for, this mean result for x, y, and z being probably more accurate than if no approximation had been attempted.

A final example may illustrate this last case.

Suppose that with one battery of 100ω internal resistance and $R=0$, A found the preliminary values of f and e (l being 1000ω)

Then by equations (8), (9), and (10)

$$f=1100\omega,\quad e=887{\cdot}5\omega.$$

$$x=733\omega,\quad y=267\omega,\quad z=367\omega,$$

These values and equation (13) give

$$R_f=1233\omega.$$

A now repeats f and e, with $R=1233\omega$ and $R=0$. Suppose he finds

$$f_1=1180\omega,\quad e_1=887{\cdot}5\omega.$$

Then by equations (8), (9), and (10)

$$x_1=706\omega,\quad y_1=294\omega,\quad z_1=474\omega.$$

Which by equation (13) supply

$$R_f=1536\omega.$$

A now repeats f and e, with $R=1536\omega$ and $R=0$. Suppose he obtains

$$f_2=1200\omega,\quad e_2=887{\cdot}5\omega.$$

Then by equations (8), (9), and (10)

$$x_2=700\omega,\quad y_2=300\omega,\quad z_2=500\omega,$$

and these values in equation (13) give

$$R_f=1583\omega.$$

A now repeats f and e, with $R=1583\omega$ and $R=0$. Suppose he obtains

$$f_3=1200\omega=f_2,\quad e_3=887{\cdot}5\omega=e_2.$$

Then the accepted final values of x and y would be 700ω and 300ω respectively, while in observing f_3 and e_3 with an electromotive force of twenty volts in the battery, the current in the fault would be 3·6 milliamperes in each case.

We have now considered both methods of maintaining a constant current in the fault. The first, by a variable electromotive force, is given in outline in the work on "Testing," by the late Mr. Schwendler. The latter, by a variable resistance, is developed from Mr. Kingsford's paper already mentioned. Of the two, it is the more convenient, practically, and involves less arithmetical labour; but, where no rheostat is available, Schwendler's method has to be adopted.—Yours, &c.,

A. E. Kennelly,

Lisbon, 29th December, 1885.

THE DYNAMO AS A GENERATOR AND A MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

Sir : I have been vastly interested in the articles on "The Dynamo as a Generator and a Motor," and my experience (which extends over the last fourteen years), to a great extent, has been the same as Sir David's in the matter of the best generator making the best motor. I can quite agree with Mr. Walker that we have not advanced much the last eight years. The fact that I have discovered in the course of my experimenting with all sorts of shapes of motors is that the generator in *general* shape is the right one, but has to be slightly altered in details when used as a motor; when a motor is so altered there is a gain of 30 per cent. in the output with the same strength of current. As I could not give these details without trespassing too much on your valuable space, I will send them to any manufacturer of motors who will write to my address.—Yours, &c.,

Wm. Aldred.

5, Brightside Bank, Brightside, Sheffield,
February 9th, 1886.

(*For continuation of* Correspondence *see page 271.*)

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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PROFESSOR HUGHES' NEW DISCOVERIES.

It has often been said that any scientific observer who deserves to be called "keen" in the popular sense of the term, and not merely "close" in the scientific sense of it, must be one who, while keeping his main object constantly in view, takes notice of everything he meets in his pursuit of it. For such a man nothing is overlooked by the way; new facts are noted down, every strange phenomenon is treasured for future investigation, and nothing is neglected as trivial. Professor Hughes is an observer and experimenter who answers to both these descriptions; he has a keen eye for results, and a close one for accidentals on the road. The incident of the sounding box mentioned during the presidential address the other evening, though not described in the printed paper, was an illustration of this. The Induction Balance itself, which was the instrument employed for making the discoveries laid before the Society of Telegraph-Engineers and Electricians, may be cited as the result of a similar accident falling under the notice of a man who has eyes to see and the genius to appreciate its significance. This contrivance was for a time chiefly remarkable for its extreme sensibility; its utility was by no means so evident, and although in the inventor's hands its performances were startling enough, there prevailed a pardonable scepticism as to its usefulness in anybody else's. Even when manipulated by himself its revelations seemed, to say the least, ambiguous, and though they pointed plainly to somewhere, nobody but himself, perhaps, could see precisely to where. Presently the accumulation of observations removed this uncertainty to a great extent, and now whenever Prof. Hughes announces another instalment of his experiments the public confidently expect to be taken appreciably nearer a solution of the mystery of magnetism and the hardly less mysterious phenomenon of electricity. Thanks to an ingenuity which is almost as remarkable as his insight, he is able to sustain this interest, not only by fresh revelations but by making them perfectly intelligible.

The chief value of the latest of these contributions probably is in their practical bearing upon the erection and material of telegraph and telephone wires. Indirectly they will throw some helpful light on the construction of dynamos, and not improbably, we think, on the manufacture of submarine cables, though the lecturer himself did not explicitly refer to either of these important industries. Considerable uncertainty has long prevailed as to the true character of induced currents and their relation to the conductor, to say nothing of the extra currents and retardation which are among the chief troubles of electric telegraphy. By a singularly bold and ingenious adaptation of the Wheatstone bridge principle, combined with his Induction Balance, Prof. Hughes has contrived a method of investigation which promises fairly to set these doubts at rest. Using, as throughout all his recent experiments he has done, the telephone as the tell-tale instead of the galvanometer, which would be useless in this connection, he is able to detect the nicest differences in wires of different material and varying dimensions, and by means of the sonometer with its movable indicator, to measure exactly the proportional variations of current induced in the wire experimented upon. It has long been suspected that the so-called resistance of any conductor differed when under the influence of a rise and fall of the current. The stable period is arrived at by maintaining a continuous current, and it is at this point that resistance is usually measured. But when used for telegraphic, telephonic, or electric lighting purposes rapid variations occur which give rise to the phenomena of induction; and it is then that, as Prof. Hughes has demonstrated, considerable difference in the normal resistance of the wire sets in, and the effect is aggravated by every additional electro-magnetic coil in the system. He finds that iron telegraph wire under rapid currents with which it is worked has a resistance three times greater than what is supposed to be its true resistance. And as the variation between the two periods differs in different classes of conductors, it follows that the ordinary resistance tests, regarded as a criterion of working capabilities, may be and probably often are somewhat illusory.

For various reasons, made conclusive by these experiments, iron is seen to be far inferior to copper both as a conductor and on account of its susceptibility to self-induction. Except in the stranded form, in which condition it is nearly equal to copper, iron exhibits the greatest electromotive force for the extra current, whilst German silver, mercury, and carbon exhibit the least, copper occupying a position very little above them. But this is true of wires only of similar dimensions; for it is found that above a certain maximum diameter of wire a marked decrease in the electromotive force of the induced current takes place with each further sectional increase, and that the maximum varies in different metals. It is also noticed that in telephone circuits, when a return parallel wire is used, the extra currents are reduced only fifteen per cent. in the case of iron, whereas a diminution of eighty per cent. is obtained when the wires are of copper. Moreover, iron wire, besides being peculiarly sensitive to all physical changes, which have, as the Induction Balance shows, a marked influence on electrical self-induction, is greatly affected by its magnetic condition. To quote the lecturer's own words, "Iron well annealed has much less resistance than the same iron when

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hard drawn, and soft iron is generally employed for telegraph lines; but during the variable period"—that is, during the actual working period—"a curious reversal takes place, as then soft iron has a higher resistance than hard iron. This apparent anomaly is easily explained if we compare the far higher self-induction of soft iron. Work is done at the expense of electrical energy, and the apparent higher resistance is due to the greater electro-magnetic action in soft iron. An iron wire shows traces of remaining circular magnetism after the passage of a continuous current, reducing the following extra currents 10 per cent." Subjected to mechanical vibrations, as are to some extent all suspended wires, iron betrays, under the influence of reverse currents, properties which materially impede the speed of telegraphic signalling. Generally speaking, Prof. Hughes favours those telegraph instruments which require only a single current for each letter, as they tend to lessen the practical difference arising from the use of iron wire and copper wire.

Some very instructive facts were also made known as to the relative merits of wire of different structure. We have already alluded to the stranded wire. It is stated sixteen fine iron wires twisted together as a stranded wire have eighty-eight per cent. less induction than a solid wire of similar weight. This difference, however, is not nearly so marked in the copper wire, for reasons which are sufficiently explained by its non-magnetic character, although it still maintains its relative superiority over iron. But the comparison between circular and ribbon wire is of still greater interest. The advantages of the latter have been already suspected, and Prof. Hughes has now computed and explained them. By employing ribbon conductors the self-induction is reduced eighty per cent. in iron, and thirty-five per cent. in copper; and, in short, there are good grounds for concluding that the resistance of a conductor, or the metal of which it is composed, have less influence on its self-induction than has the form of the conductor. This circumstance has an important application in the winding of electro-magnetic coils, but especially in the construction of lightning conductors. These experiments have confirmed the opinion that a solid rod of iron is the worst possible outlet for lightning discharge. The conductor, if of copper, should be of ribbon form, or if of iron, of numerous stranded wires, or a wide ribbon of similar conductivity to that of copper. Prof. Hughes's paper was discussed last night while we were going to press; but whatever criticism it may have been subjected to on certain points, there will be no difference of opinion as to the great practical value of the discoveries he is making by the assiduous use of his exquisite little instrument, the Induction Balance.

NOMENCLATURE.—III.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I number this III. as being my third note on the subject. In my first, amongst other things, I remarked that whilst the conduction current terminology admitted of the words resistivity and conductance being coined to make it more complete, the terminology in the allied cases of magnetic induction and electric displacement was unsatisfactory.

As regards the former, the following appears to me to be practical. First, abolish the word permeability, and substitute Inductivity. We then have $B=\mu H$, when B is the Induction, and μ the Inductivity, showing how the Induction is related to the magnetic force H by the specific quality of the medium at the place, its inductivity.

Now conductivity and conductance are mathematically related in the same manner (except as regards a 4π) as inductivity and what it is naturally suggested to call Inductance.

The Inductance of a circuit is what is now called its coefficient of self-induction, or of electromagnetic capacity.

Thus the quantities induction, inductivity, and inductance are happily connected in a manner which is at once concise and does justice to their real relationship. When the mutual coefficient of induction of two circuits is to be referred to, it will of course be the mutual inductance.

I may perhaps also be allowed to mention, whilst on the subject of nomenclature, a difficulty thrown in the way of learning by the S.T.E. and E., which some time ago had some trouble with its own nomenclature. Having changed name three times, it might be called "The Society of Variable Nomenclature and of the Redundant Conjunction." I should like it to have been called simply "The Electrical Society," following the example of so many other societies who are satisfied with simple and comprehensive names. For instance, the Physical Society does not call itself the Society of Physicists and of Natural Philosophers, nor does the Mathematical Society call itself the Society of Mathematicians and of Arithmeticians or Geometricians. But that is not the point to which I would refer, which is, that the S.T.E. and E. has its journals sewed and wired in such a manner that a real difficulty is placed in the way of getting at their contents. They won't lie open, for one thing, which has been called the unpardonable sin of book; they must therefore be held open; more than that, they must be strongly stretched before the words nearest the wires become readable, as they are nearly hidden by reason of the curvature. It is as exasperating as a tight boot.—Yours, &c., OLIVER HEAVISIDE.

MEASUREMENT OF INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The author of the paper on the "Calorimetric Measurement of Incandescent Lamps" in your last issue appears to have ignored the two important factors in connection with the amount of heat given off by incandescent lamps, viz., the efficiency at which the lamps are run and the perfection of the vacuum. The latter he of course could not only have determined approximately, but the former was merely a question of calculation, and as the four incandescent lamps tested appear all to have been run at different efficiencies the value of the table given at the end of the paper is thus negatived.—Yours &c., E. S.

INSURANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to the inquiry of "Insurance" in your issue of 5th inst., I may mention that this company is prepared to receive proposals for insurance against accidents from electrical engineers. The circumstances in each case are, of course, taken into account, but ordinarily a premium of £6. 5s. provides the following benefits:—

£1,000 in the event of death or permanent total disablement; £500 in the event of permanent partial disablement; £6 per week during temporary total disablement; and £1. 10s. per week during temporary partial disablement.—Yours, &c., J. MOODY STUART

(Fellow of the Institute of Actuaries), Manager

Scottish Economic Life Assurance Society (Limited),
34, King-street, Cheapside, 10th Feb., 1886.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter from "Insurance" which you published in your last issue raises a point which I should be glad to see elucidated, and some practical result obtained in the way of a definite classification from one or more of the accident insurance companies.

My own experience has been as follows:—I insured about four years ago in a well-known company, and I took out a full policy, paying the premium for extra risks. About this there was no difficulty. About a year afterwards I was induced by one of my friends, who has an agency for another company, to

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transfer my policy to that company. This I did, taking as before a full policy, and paying the premium for medium risks. I have regularly renewed this policy until quite recently, when I was desirous of taking out a policy for a smaller amount, as I considered that the work I was engaged in at the time, and was likely to be engaged in, was much less hazardous than had previously been the case.

I therefore applied to the company for another policy for half the amount of the previous one, and also to know whether they would grant the policy under the "ordinary risks" instead of the "medium risks," and I pointed out why I considered my risks were less than heretofore. Among other things, I stated that my work was largely experimental.

In reply I was informed that I could be insured under ordinary risks if the policy were endorsed to exclude risks from *electrical experiments*. I replied that I did not consider it advisable to take out a policy which did not cover all risks, and I would therefore take out the policy, as heretofore, under "medium risks," but for half the previous amount. In reply, I was informed that they would only grant a policy which excluded risks from *electrical experiments*.

I did not trouble myself to argue the matter with them, but allowed it to drop, as I thought that such ignorance was not worth further argument.

A good deal might be done, however, by concerted action, and I shall be glad to place myself in communication with "Insurance," or any other of your correspondents or readers who wish to take up the matter, with a view to making proper representations to one or more of the Accident Insurance Companies.—Yours, &c., R. I. S. K.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to a letter in your issue of the 6th inst., signed "Insurance," I beg to say that the subject of insuring electrical engineers has received the attention of this company, and it has arranged to place them in the same class of risk as civil engineers. I shall be happy to supply terms on application.

I may add that this company already has amongst its policy-holders electrical engineers connected with some of the best known Electric Lighting Companies in the country.—Yours, &c., A. B. SHELLEY, Secretary.

Imperial Union Accident Assurance Company (Limited), 32, Finsbury-pavement, London, Feb. 11, 1886.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Two letters in your current number need notice. One, the important communication under the signature of "Insurance," if correct, indicates serious error on the part of the accident companies; but an error which has doubtless been fostered by the obstinate refusal of information as to the number and severity of the accidents which have hitherto occurred. At the same time, as a medical insurance officer of over twenty years' experience, I can affirm that the real reason for refusing a risk is not always that alleged by the person declined or his friends.

The second is the renewed howl of Mr. J. Johnstone in favour of his "Electric Boy." To his former ululation I did not reply, because it contained no new facts and was discourteous. "Hamlet" stepped in and at once made the matter clear. I did not venture even to "insinuate" that Mr. J. J. had been humbugged; but "Hamlet" (who had some experience in imponderable matter) seems to do so.

To one statement in Mr. J. Johnstone's second letter I must categorically demur. "If the electricity in the boy's body," he states, "came up from his feet, his legs when touched ought to have given a shock stronger, or as strong as that obtained from his body."

I strongly advise Mr. J. to patent his new source of electricity "inhaled" in breathing; for it is entirely novel, and is a "Thierische Elektricität" of the most startling nature. Only it would be well if he were first to demonstrate its existence.—Yours, &c., WILLIAM H. STONE.

Sanctuary, Westminster, S.W.

THE STEAM ENGINE INDICATOR.—XV.*

BY AMICE.

We may now turn our attention to the compound engine, and should, perhaps, first explain that the engine at present made under this name is old in conception, has been made for many years, but has become a more simple and more economical engine by modern developments. For these developments we have been chiefly indebted to marine engineers, who have by their practice shown that not only can high-pressure be used with an approximately equable turning movement on the crank-shaft, but that the reduction in size of engines obtained by this use of high-pressure is attended with no disadvantages, and the engines are more economical than the simple engine. The compound system has now been developed to the extent of performing the expansion in three cylinders, or by what are known as triple expansion compound engines, and almost all new vessels are being fitted with them. The adoption of the compound system has extended to land engines of almost every kind, and most recently to locomotive engines; and it is especially suitable for electric lighting work, because this work is uniform, and the advantages of the compound engine can only be fully obtained when the work it performs is approximately uniform.

We have already referred to the condensation which takes place in steam engine cylinders as a result of the fall in temperature of the cylinder, due to the fall in pressure during expansion. It is obvious that the condensation due to this cause will be greater as greater ranges of expansion are adopted. The limit to useful expansion in a single cylinder is thus controlled, and therefore the limit to useful high-pressure is also soon reached. For instance, in the case of a simple engine no good purpose can be served by adopting a terminal pressure of less than about three to five lbs. per square inch. On the other hand, the advantages of high ratios of expansion are counterbalanced by the condensation which attends them. The higher limit of pressure will thus be fixed by selecting the most economical range of expansion. If this be, say, six, then allowing for condensation, which is inevitable even at this ratio, and taking into consideration the economical advantage which attends the use of higher pressures in making engines smaller for the same work, and thus taking less steam for moving their own parts, the maximum useful pressure will not exceed from 40 to 50lb. per square inch, except where high pressure is specially useful in reducing the size of the engine.

A comparison of the possible advantages may be better or more readily seen by taking pressures and ratios of expansion, and, for the sake of illustration, making no allowance for losses. Thus a sixfold expansion in a simple engine would, if the terminal pressure be 5lb., need an initial pressure of 30lb. The specific volume of steam at 30lb. (see p. 227), is 881. If now, on the other hand, practical conditions are so altered that we can safely and economically use any range of expansion, the terminal being as before 5lb., and the initial pressure 150lbs. (quite common now), we could use a range of $150 \div 5 = 30$. Now, the specific volume of steam at 150lb. per square inch being 203, one volume of such steam expanded 30 times would give us 6,090 volumes. On the other hand, the 30lb. steam would give $881 \times 6 = 5{,}286$. In practice, however, such a very large ratio of expansion would be impossible, the losses attending the use of the very high-pressure and temperature would be considerable, and five cylinders would be required to perform the expansion even in five-fold stages. With 150lb. steam, a ratio of from 15 to 20 might be used, and with the 30lb. steam not more than 3; so that the economical advantage is still, in spite of practical obstacles, on the side of high-pressure, while the engine for the purpose will weigh less and occupy much less space, a gain which is much greater when the space occupied by the boilers is taken into consideration.

The compound engine, therefore, whether with two, three, or four cylinders in series, is gaining ground rapidly, and for such purposes as electric lighting, driving mill machinery, or as marine engines, will no doubt wholly replace the simple engine. We must, then, consider the application of the indicator to

* For Art. 14, see *The Electrician*, 29th January, 1886.

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engines of these classes, and then deal with the problems which appear in connection with the several diagrams from the two or more cylinders. In the compound engine with two cylinders in series, the steam from the boiler is first admitted to a smaller cylinder, where the cut-off will be from one-third to, say, one-half the stroke, or the ratio of expansion from 2 to 3. From this cylinder the steam is exhausted, or is allowed to pass into a larger cylinder either with a receiver between the two, or with only the steam valve chest and passages between the two cylinders. The steam is perhaps cut off at from half-stroke to three-fourths in this cylinder, according to its size. The re-relative sizes of the cylinders and the cut-off in both cylinders are arranged so as to obtain as nearly as possible the same amount of power from both. The pressure in the low-pressure or second and larger cylinder is always active as back pressure in the high-pressure cylinder, and thus cutting off in the low-pressure cylinder only tends to increase the back-pressure in the high-pressure cylinder towards the end of its stroke. This may not be harmful, but the amount of this will be determined by the same considerations as those which would determine the most useful amount of compression in a simple engine, and by the amount that may be usefully used when necessary to balance the power of the two cylinders by this means. Assuming the two cylinders to be proportioned exactly to the pressure and work to be done, then the total expansion in a two-cylinder compound engine will be equal to the volume of the low-pressure cylinder divided by the volume of the steam admitted to the high-pressure cylinder to the point of cut-off, and in this case the back-pressure in the high-pressure cylinder will not increase towards the end of the stroke of the low-pressure cylinder, as the cut-off in the low-pressure cylinder will be practically at the end of its stroke.

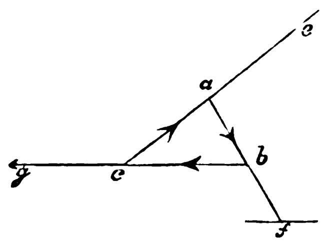
ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 247.)

*Grassmann's Theory.**

The method by which Grassmann obtains his theory is very remarkable. He objects to Ampère's formula for the force between two elements of current, because it makes the force between two parallel elements change from an attraction to a repulsion when the angle which the elements make with the line joining them passes through the value $\cos^{-1} 2/3$, and the object of his investigation is to get a law of force free from this peculiarity, and which, while giving the same result as Ampère's for closed circuits, shall yet be as simple as possible. He begins by regarding any circuit as built up of "winkelströme," *i.e.*, currents flowing along the two infinite lines which form any angle. He points out that a circuit of any shape



can be built up of such currents. The circuit *a b c*, for example, may be regarded as built up of the "winkelströme" *e a f*, *f b g*, and *g c e*. Grassmann proceeds to calculate by Ampère's formula the action of a "winkelstrom" upon an element of current (α). Since the "winkelstrom" will have no action upon an element of current perpendicular to its plane, we see that it is only necessary to calculate its action upon the component (α') of α in its own plane. Grassmann does this by calculating the effect due to each arm of the "winkelstrom" separately. He finds expression for the forces along and perpendicular to α' due to an infinite rectilinear current starting from a definite point. The force of such a current along α' does not depend on the angle the current makes with the line from its end to α', so that the effects of two such currents starting from the same point, and flowing in opposite directions, *i.e.*, of a "winkelstrom," will be to produce no force along α'; thus the effect of a "winkelstrom" on an element of current in its own plane will be a force at right angles to the element. The force at right angles to α' due to a rectilinear current will consist of two parts, one independent of the angle made by the current with the line joining its end to the element, and the other depending upon this angle. The first part will vanish when we consider a "winkelstrom;" the second part only will produce any effect.

Now, Grassmann says that it will much simplify the analysis, and obviously (since any closed circuit may be built up of "winkelströme") lead for closed circuits to the same result as Ampère's formula, if we suppose that the law of force between elements of currents is such that the only effects produced by a rectilinear current are those which do not vanish for a "winkelstrom;" and hence that a straight current exerts on an element of current a force at right angles to the projection of the element on the plane containing the centre of the element and the rectilinear current, and that the magnitude of this force is

$$\frac{i\,j\,ds'}{r}\cot\frac{\alpha}{2}$$

where i is the strength of the rectilinear current, j the strength of the element of current, ds' its projection on the plane through its centre containing the straight current, r the distance of the element from the end of the straight current, and α is the angle which the rectilinear current makes with the line joining its extremity to the elementary current. By taking the difference of two such rectilinear currents, Grassmann finds the action of an element (β) of current on another element (α) is a force at right angles to α', the component of α in the plane containing β, and the middle point of α, and equal to

$$i\,j\frac{d\sigma ds'}{r^2}\sin\theta,$$

where θ is the angle which β makes with r, $d\sigma$ the length of (β), and j the current flowing through it.

The direction of the force is along A B, where A is the centre of the element (α) and B the point where the normal to α' is cut by β, produced *in the direction* of the current.

If we treat this theory in the same way as we did Ampère's, by considering the action of the components α_1 β_1 of an element of current ds_1 on the components α_2 β_2 γ_2 of another element ds_2, we see that Grassmann's theory is equivalent to supposing that α_1 exerts no force on α_2 β_2 or γ_2; that β_1 exerts a force $A\beta_1$ α_2 on α_2 at right angles to α_2 in the plane of *xy*, and a force $A\beta_1$ β_2 on β_2 at right angles to it—that is, along the line joining the element, and that it exerts no force on γ_2. Thus we see that Grassmann's theory is equivalent to replacing Ampère's assumption that the force between two elements of current acts along the line joining them, by the assumption that two elements of current in the same straight line exert no force on each other.

As a dynamical theory of electrodynamics, Grassmann's theory is open to the same objection as Ampère's, that it does not take into account the couples which may exist between the elements, and also to the additional objection that according to it the action of an element of current ds_1 on another element ds_2 is not equal and opposite to the action of ds_2 on ds_1, that the momentum of the two elements ds_1 and ds_2 will not remain constant; and as the theory does not take into account the surrounding ether, there is no way of explaining what has become of the momentum lost or gained by the elements. As a piece of geometrical analysis, however, the theory is very elegant, and worthy of the author of the "Ausdehnungslehre."

From the way in which Grassmann's theory was developed, we see that between closed circuits it must give the same forces as Ampère's; for unclosed circuits this is not the case, and Grassmann, at the end of the paper quoted above, mentioned a case where the two theories would give opposite results, assuming that unclosed streams exist. Suppose we have a magnet Ns, and an unclosed current AB in the same plane as the magnet, and passing through its middle point, then, if

* *Pogg. Ann.*, 64, p. 1, 1845. "Crelle," 83, p. 57.

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Ampère's theory be true, the magnet will twist in one direction; if Grassmann's, it will twist in the opposite. This depends upon the change, according to Ampère's theory, of the force between two parallel elements, from attraction to repulsion, when they make the angle with the line joining them at less than $\sin^{-1} 1/\sqrt{3}$, while, according to Grassmann's theory, there is no such change.

*Stefan's Theory.**

This resembles Ampère's theory very closely, except that Stefan does not make the assumption that the force between two elements of current is along the line joining them. This difference leads to the introduction of two forces which Ampère neglects. We shall use the same notation as when we discussed Ampère's theory, and consider, as before, the action of an element of current ds_1 on another element ds_2. Stefan, like Ampère, assumes that we may replace an element of current by its components, so that we have to consider the action of the components $(\alpha_1 \beta_1)$ of ds_1, or the components $((\alpha_2 \beta_2 \gamma_2)$ of ds_1.

As in Ampère's theory the component α_1 is supposed to exert a force $\frac{a\,\alpha_1\,\alpha_2}{r^2}$ on α_2, this force by symmetry must be along the line joining the elements; α_1 is supposed to exert a force on β_2 equal to $\frac{c\,\alpha_1\,\beta_2}{r^2}$ along the axis of y.

We can see that this force may exist, for it is conceivable that it should be in the same direction as β_2 when α_1 points from the middle of ds_1 to the middle of ds_2, and in the opposite direction to β_2 when α_1 points in the opposite direction.

Stefan assumes that α_1 exerts no force on β_2 parallel to the axis of z, and no force at all on γ_2.

β_1 is supposed to exert a force on α_2 parallel to the axis of y and equal to $\frac{d}{r^2}\,\beta_1\,\alpha_2$.

We may see by the same reasoning as we used before for the force between β_1 and α_2, that it is conceivable that this force may exist. β_1 is supposed to exert no force on α_2 parallel to the axis of z. As in Ampère's theory β_1 is supposed to exert a force on β_2 equal to $\frac{b}{r^2}\,\beta_1\,\beta_2$, this force must by symmetry be along the line joining the elements; β_1 is supposed to exert no force on γ_2.

Thus the action of ds_1 on ds_2 consists of a force

$$\frac{1}{r^2}\left\{ a\,\alpha_1\,\alpha_2 + b\,\beta_1\,\beta_2 \right\}$$

along the line joining the elements, and a force

$$\frac{1}{r^2}\left\{ c\,\alpha_1\,\beta_2 + d\,\beta_1\,\alpha_2 \right\}$$

at right angles to this line in the plane containing ds_1 and r.

If we take arbitrary co-ordinate axes, and suppose that $x,\ y,\ z$ are co-ordinates of ds_1, $x^1\ y^1\ z^1$ those of ds_2, then the x component of the force on ds_2, due to ds_1, is shown by Stefan to be equal to

$$i\,j\,ds_1\,ds_2 \left\{ m\frac{d_2}{ds^1\,ds_2}\,\frac{(x^1-x)}{r} + n\frac{d}{ds_1}\,\frac{1}{r}\,\frac{dx^1}{ds_2} + p\frac{d}{ds_2}\,\frac{1}{r}\,\frac{dx}{ds_1} + q\,\frac{x^1-x}{r^3}\cos\epsilon \right\}$$

with similar expressions for the force parallel to the axes of y and z.

Here $i,\ j$ are the currents through $ds_1\ ds_2$ respectively, ϵ is the angle between the elements of current and

$$m = -\frac{1}{3}\left\{ a - b - c - d \right\}$$

$$n = \frac{1}{3}\left\{ a - b - c + 2d \right\}$$

$$p = -\frac{1}{3}\left\{ a - b + 2c - d \right\}$$

$$q = \frac{1}{3}\left\{ a + 2b - c - d \right\}$$

We see from this expression for the force parallel to x, that the last term is the only one which does not vanish when integrated round two closed circuits of which ds_1 and ds_2 are elements. So that the force will depend only upon q.

The value of q will depend upon the units we adopt. In Stefan's work q is put equal to $-\frac{1}{2}$. This is the only condition to be got by considering the translatory force between two circuits; we can get another by considering the couple acting on the closed circuit, supposed rigid, of which ds_2 forms a part.

For the Z component N of this couple Stefan finds the expression

$$N = i\,j\,q\iint\frac{y^1x - x^1y}{r^3}\cos\epsilon\,ds_1\,ds_2 - i\,j\,p \iint\frac{1}{r}\left\{ \frac{dx^1}{ds_2}\,\frac{dy}{ds_1} - \frac{dy^1}{ds_2}\,\frac{dx}{ds_1} \right\} ds_1\,ds_2.$$

But supposing the two circuits to have a potential

$$i\,j\iint\frac{\cos\epsilon}{r}\,ds_1\,ds_2$$

we can easily see that the couple

$$= i\,j\iint\frac{y^1\,x - x^1\,y}{r^3}\cos\epsilon\,ds_1\,ds_2 - i\,j\iint\frac{1}{r}\left\{ \frac{dx^1}{ds_2}\frac{dy}{ds_1} - \frac{dy^1}{ds_2}\frac{dx}{ds_1} \right\} ds_1\,ds_2.$$

Thus, if two circuits have a potential

$$p = q,$$

or substituting for p and q their values,

$$2a + b + c - 2d = 0.$$

If $c = 0$ and $d = 0$, as in Ampère's theory, this relation becomes

$$2a + b = 0,$$

which is the same relation as Ampère deduced, by finding the condition that the force due to a closed circuit on an element of current should be at right angles to the element, and Stefan has proved that on his theory the same condition leads to the equation

$$p = q,$$

i.e., the same condition as the one which expresses that two closed circuits have a potential.

Stefan shows that from the consideration of the action of closed circuits on elements of other circuits, or of themselves, it is impossible to get any other relation between the quantities $a,\ b,\ c,\ d$, so that we have only two relations between the quantities $a,\ b,\ c,\ d$, and thus two of them must be indeterminate.

We may give any values we please to these quantities, provided they satisfy these two relations. If we put $c = 0$, $d = 0$, we get Ampère's theory; if $a = 0$, $c = 0$, Grassmann's, and we can get a number of other theories by giving different values to these quantities.

Stefan's theory is open to the same objection as Ampère's, since it does not take into account the couples which one element may produce on another. He also limits the generality of his theory by supposing that the force between two elements of currents in one plane is in that plane.

(To be continued.)

* Stefan, *Wien Sitzungsberichte*, 59, p. 693, 1869.

THE MAXIM-WESTON ELECTRIC COMPANY (LIMITED).—The Directors of this Company give notice that the fifth annual ordinary general meeting of the Company will be held at the Cannon-street Hotel, on Friday, the 19th inst., at two o'clock, to receive from the Directors a report and statement of accounts of the Company for the year ended 31st December, 1885, to elect two Directors and an auditor in room of those who retire by rotation, and to transact the ordinary business of the Company. The Directors, in their report, remind the shareholders that no allowance was made during the past two years for contingencies such as are referred to in Section R of Clause 75 of the articles, and they have now deemed it prudent to pass the sum of £3,606. 5s. to the credit of a general reserve account. After making the above reserve the total balance at credit of profit and loss account, including amount brought forward from previous year, is £5,284. 19s. 8½d. The Directors recommend the payment of 7½ per cent. dividend, which will leave a balance of £597. 9s. 8½d. to be carried forward to next year. The Directors proceed to refer to the reduction of capital by which means the Patents account has been reduced to £35,000. The Directors are happy to be able to report a rapid development of the business, and having now established agencies in nearly every quarter of the globe, which their Patent rights include, are in hopes of showing a larger balance of profit at the end of the current year. The Chairman (Mr. Hugh Watt, M.P.) trusts to be of some service in obtaining the removal of restictive legislative enactments, and is in hopes that the Government will approve of certain amendments to the Acts of 1882, which ought to give a further stimulus to the business.

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COMPANIES' MEETINGS & REPORTS.

The Anglo-American Telegraph Company.

The ordinary general half-yearly meeting of the proprietors in this Company was held at the City Terminus Hotel, Cannon-street, on the 15th inst., under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. T. H. Wells) read the notice calling the meeting and the minutes of the last meeting, which were approved and signed by the Chairman as correct. The report was taken as read.

The CHAIRMAN, in moving its adoption, said that when he last addressed them he was obliged to tell them, as was the fact, that several of their cables on the other side of the Atlantic had suspended action. They were aware that quite independently of the cables which carried the traffic of the Company across the Atlantic they had a regular system of cables on the other side connecting those cables with the different seats of traffic in America. Those short cables were nearly all out of order when he last addressed them ; but he had now the pleasure of telling them that they and the whole of the rest of the system were now in perfect order and working with efficiency. There was not a single mile of their plant now that was not in perfect order. That was, of course, a very important consideration, because, no matter what their condition might be in other respects, if their plant was not capable of carrying their traffic they could expect no results from it. He was, however, very sorry to say that he could not give them a very satisfactory account of the traffic itself. The competition still continued. The truth was that the public in their wisdom had put down in the Atlantic such a number of cables that the traffic at present did not afford a living to any of them, and his belief was that a living could not be afforded to any of them without one of two things occurring. One relief might be obtained by a very large increase in the traffic ; but he was very sorry to say that the experience they had had of now nearly twenty years, having tried tariffs of all sorts, high and low, that they could not find that there was that elasticity in the traffic which would enable the number of cables that now existed in the Atlantic to live and make a profit. It was an old saying that they could not take a quart of liquor out of a pint pot, and really that homely phrase illustrated perfectly the condition of things in the Atlantic. It appeared to him that unless a return of prosperity in trade made a great change in the Atlantic traffic, that they had completely exhausted the elasticity of that traffic. The only other alternative was one which the public would not like, but it was one which he had more than once had to declare would be the result of inordinate competition, namely, that the rates must be raised. There was an old saying, that where combination was possible competition was not likely to continue, and with the small number of people whom it was necessary now to bring into agreement in order to raise the rates of Atlantic telegraphy, his belief was that the rates would be raised—raised, as one of his friends suggested to him, to a paying figure. They had been hoping and expecting for some time that that would take place, and he could not help thinking that the time was not far distant when that would be so, and he would give them his reasons for that opinion. The gentlemen who placed the last two cables in the Atlantic were gentlemen of great wealth in America. They all knew that on this side of the Atlantic we were obliged to be satisfied with a very moderate rate of interest on our investments, but that was not the case on the other side of the Atlantic. In the United States they required a much larger rate of interest for their money in order to be satisfied with it than we did here, and he believed that those gentlemen, after the experience they had acquired by the last year's transaction of their business, would not be very much gratified with the return which the large outlay which they had made on those two cables had brought them in, and he believed that that consideration would before long have its weight, and bring them to a state of mind in which they would listen to reasonable terms. At all events, if that were not the case—if events did not take that course—this Company had always the power of drawing the sword. There was a limit to forbearance. They were unwilling to throw away more money in what was called a battle of rates ; but of course if nothing else would do they must come to that at last. He did not mention this by way of threat, but it was a fact that they must all look in the face, and if they had to go into a battle of rates they were in a very good position to carry it on. They had a perfectly efficient system, and, as he had said, the plant was in good condition, and, moreover, they had what he was going to call their old enemy—their very large renewal fund—at the back, which would give them strength in fighting such a contest. Having said so much about the state of the traffic in the Atlantic, he now wished to say a few words about the accounts. Of course it was the duty of their Directors, at a time when the receipts were coming in so slowly, to do their utmost to economise in the administration of their affairs, and he thought if they would compare the accounts of the last half-year with those of the corresponding period of 1884, they would find that economy had been exercised in almost every item. There was a a reduction in almost every item of the accounts, beginning with the expenses at the head office in London, upon which the reduction had been £221 in the year. That did not seem a large sum, but it showed that the Board were working in the direction of diminishing the expenses. They could not expect a very large reduction in the working expenses of one half-year, but the fact he had mentioned showed that they were endeavouring steadily to keep them down. The difference in the expenditure between the two half-years at the stations was £4,800 ; but it was only right to mention that that reduction in the past half-year had been due to the cecessation of some extraordinary expenditure in the previous half-year, which was not a recurring item. There was also another matter to which he desired to call attention. If they looked at the revenue account for the last half-year they would see that the repairs of cables (which of course was the result of the state of things to which he had alluded at the beginning of his remarks) had cost £11,376, consisting of the expenses of their steamship, "Minia," £10,417, and the value of cable expended £958. However, the "Minia" was not engaged in repairing the Company's cables the whole half year, and they chartered her to other companies, and obtained £10,270 in that way. Therefore their Company had their repairs last half year effected for very little more than the cost of the cable expended in carrying out the operation. That he thought showed that the Board were getting in every penny they could in every direction, and trying to keep down expenditure in every possible way. With respect to the old subject of debate in that room—namely, the renewal fund, probably they would have seen in the papers an account of a meeting of stockholders in reference to that matter. Those gentlemen met two or three weeks ago and appointed a committee, who asked to have an interview with the Directors. Within the last year a very important constitutional question had been settled, as it was called out of doors, by a meeting between the members of the Ministerial party and those in Oppositon, and they on that Board were not at all above adopting so good a precedent whenever they saw it occur, and they at once acceded to the request of the gentlemen of the committee that they should have an interview with the Directors. They would remember he had told them—he believed it was at the last half-yearly meeting—that the Board had determined to reduce the contribution to the renewal fund, owing to considerations which they had themselves formed, from £150,000 to £100,000 a year. That arrangement, it was decided, was to continue for three years, after which the contribution was to be further reduced. After a conference with the committee, however, at the beginning of this week, they had come to the decision that as soon as the renewal fund had reached the sum of one million, they would put no further accretion to it from the revenue, and that the only sum that should be added to it after that period should be the interest on the renewal fund itself. That resolution was accepted by the committee as satisfactory. The resolution of the Board, he ought to say, was conditional on no break-down taking place within the next year, because if any of the cables gave out they would have to replace them, and to reconsider their decision. He might, for better certainty, read the minute of what took place between the committee and the Board at the conference to which he had alluded. "The Anglo-American Telegraph Company, 2nd February, 1886. Having had a conference with a committee of shareholders with respect to the renewal fund, the Chairman stated that in the circumstances in which the Company is now placed by competition, &c., the Directors would stop further contributions from revenue to the renewal fund when that fund should amount to one million. After that date the interest alone would be added to the principal. This decision is upon the assumption that no serious disaster to the cables occurs before one million is reached. What is to be done if the fund falls below one million is left to the future decision of the Directors." That was the way the matter now stood. Mr. Smith, of York, who led the opposition to the renewal fund on former occasions, had expressed himself satisfied with the decision of the Directors, and had authorised him (the Chairman) to say that he would not put the resolution of which he had given notice in the circular which he had sent to the shareholders. He had also received a letter from Mr. Smith on the previous night, in which, in addition to what he (the Chairman) had said, Mr. Smith wished that the Directors should give an engagement that no sum beyond £100,000 should be expended from the renewal fund without the sanction of a meeting of the proprietors. That, however, involved—he was almost afraid to say it—an infraction of the Articles of Association [laughter] [A Voice : "Which we want altered"]. Mr. Smith's object could not be carried into effect without an alteration of those articles. Would they allow him in all good faith and kindliness of feeling to ask what necessity there was for such an alteration? What had been the history of the renewal fund? The object of such a proposition as that of Mr. Smith, they could, of course, all see—and it was a very just and natural object—was to prevent any expenditure of the renewal fund on anything except that for which it had been put by—that was to say, the renewal or replacement of the cables already in existence. What, however, had been the history of the Company? When he first became connected with it they had the 1865 cable and the 1866 cable and the French cable, of which he was the original Chairman. Immediately after the junction between the Anglo-American and the French Companies they laid another cable with the material which had been provided by the first French Company for duplicating their own cable. Immediately after the junction of the two companies they began accumulating the renewal fund. Therefore, none of the cables laid before that period could have been laid in any other way, or paid for in any way out of the proceeds of the renewal fund. What subsequently took place? The 1865 cable gave out, and by the terms of their agreement with their allies in the pooling transaction they were bound to replace that cable by another one. Fortunately, they had a considerable quantity of material which was to have been laid by the French Company in duplicating their cable, but the cable they put down from Ireland to Newfoundland was not nearly as long as that for which they had made provision, and therefore that large amount of material was available for laying the new cable of 1874. That cable was laid partly out of the French Company's material and partly out of the renewal fund. Therefore the only expenditure which the fund had made up to this time was in repairing (and repairs were replacements) some of the cables and assisting in laying the 1874 one. Afterwards the 1866 cable gave out, and they found it impossible to repair it, and they laid, exclusively out of the renewal fund, a new one in its place. They would all admit that the renewal fund was intended to replace the property and everything else as it gave out. He had shown them that up to this time they had never spent anything from that fund for any other purpose, and what right had they to assume that the

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Directors would do in future what in the past they had never thought of doing? Mr. Smith, in his letter, had spoken in very kind and flattering terms of the present Board, and left it to be inferred that if the present Directors were immortal he would not require such a change in the Articles of Association. But all he (the Chairman) could say was that when the present Directors passed away and another Board succeeded them, if they were not so scrupulous as the existing Board about the renewal fund, his belief was that any shareholder could obtain an injunction to prevent them from applying it to any other purpose than that for which it might be legitimately applied. The very name of the fund, he considered, would prevent them from spending it for any purpose except that of renewals or replacements. That was its object—the object for which it was created, and the only one in his belief to which it could be legally applied. That being so, why change the Articles of Association, discrediting the Directors—for it came to that—and bringing discredit on the whole enterprise itself when there was no reason, from what had occurred or was likely to occur, for making the change? Those were the reasons why he could not accept Mr. Smith's proposition, and the Board having maturely considered the subject, adhered to that view. He hoped that they would agree to go on as they had done. The shareholders had the most complete guarantee that he could conceive for the security of that fund, in which they had, in his opinion, a backbone which would support them through the disastrous events which might, but which he hoped would not, occur in the history of their enterprise. He concluded by moving the following resolution:—

"That the report of the Directors, dated 28th January, 1886, and the accompanying statement of accounts to the 31st December, 1885, and submitted to this meeting, be and the same are hereby received and adopted; and that the following dividends, less income-tax, be now declared—that is to say, first, a balance dividend of 10s. per cent. upon the ordinary consolidated stock for the year ended 31st December, 1885, making, with the previous payments, 1¼ per cent. on that stock for the year 1885; second, a balance dividend of 1 per cent. on the preferred stock for the year ended 31st December, 1885, making, with the previous payments, 2½ per cent. on that stock for the year 1885."

The Marquis of Tweeddale seconded the motion.

Mr. Chester desired to know the expenses and the earnings of the "Minia" for the whole of the past year, the chairman having given the result for the past half year.

Mr. Thos. Smith (of York) thought they might congratulate themselves that they had now seen an end to the additions to the renewal fund as from the 31st December of the present year, when they would have the full use of their net earnings. His lordship had made a slight mistake. The arrangement come to by the Directors and the committee was that at the end of the present year additions to the renewal fund should be allowed to be made only from the interest earned by the fund. The fund at the end of the present year would be short by only £18,000 or £20,000 of £1,000,000, and after that no further additions would be made to it except out of interest. He trusted that the shareholders would accept that arrangement with satisfaction as practically closing the drain on their resources, and also leaving them for future contingencies the immense sum of a million. That was a large sum, and was a grand backbone for all contingencies. They had now only to guard against its expenditure. They all heard what his lordship had said on that matter. He rather differed from his lordship; but still as they had educated him up to their views so far, perhaps they might leave Viscount Monck, and see whether, like all good Liberals, he would not advance still further. He need not say that, as a holder of all the stocks in the Company, he had been acting simply in their interests [A Voice: "And your own"], and his own of course. He had not sold any of his stock. The Directors having now made what he considered a satisfactory settlement as to any further additions to the renewal fund, he had much pleasure in taking a course which he had never done before. That was to support the adoption of the report before them. He might also say, however, in doing so, that he did not undertake to blindly follow the Directors in whatever they might propose in the future. As in the past, he intended to reserve, as a man of business, the right to act upon his own independent judgment in all matters concerning the future management of the affairs of the Company. He might state that they received a very courteous reception from the Directors at their interview. The discussions in the past respecting the renewal fund might have involved some waste of time; but after all, he did not think there had been waste of time seeing that they had got the Directors to accept their views to the extent mentioned.

Mr. Chipperfield asked the cost of the last cable laid by the Company?

The Managing Director (Mr. H. Weaver): Something over £400,000.

Mr. Chipperfield inquired whether the Directors knew how much the Mackay-Bennett cables had cost.

The Managing Director replied in the negative.

Mr. Chipperfield, continuing, said that what he desired to draw attention to was that when the renewal fund was first started the cost of laying a cable was very much larger than that of such a work now, and in view of this fact he wished to know whether it was necessary to allow the fund to grow to such a large extent. He had just been told that the last cable had cost the Company only £400,000.

The Managing Director observed that that was the actual money spent on the cable, but beyond that they had the old shore ends which they could use.

Mr. Chipperfield said that what he wished to point out was that if a cable had to be laid across the Atlantic now it would not cost more than £400,000.

The Managing Director replied that it would.

Mr. Chipperfield thought that they might take it that it would not cost more than £400,000, and he wished to know whether there was any necessity for allowing such a large sum to accrue as would be sufficient to lay two if not three cables across the Atlantic.

A Shareholder said they were very glad that the arrangement referred to had been come to between the committee and the Directors, and thought that any money which the committee were out of pocket should be made good to them.

Mr. Smith remarked that the action taken by the committee had been merely for the benefit of the whole Company.

Mr. Garner desired to protest against what the Chairman had said as to engaging in another war. He considered that their Company had nothing to do with other companies in any way. What they ought to do was to charge a reasonable and fair price, and then allow other companies if they liked to enter into competition. Had they done that in the past he maintained that they would have had a monopoly of the working in their own hands.

The Managing Director: You would have had no dividends.

Mr. Garner stated that he maintained, notwithstanding what the Chairman had said, that the proprietors had no guarantee that the renewal fund would be properly spent except the guarantee which they had in the character of the Board. They could spend the fund as they pleased, and they could have a new cable if they liked to-morrow. There was nothing to prevent them from doing that except their honour.

Mr. Chester regretted the remark made by the Chairman in his opening speech, that he believed the elasticity in the traffic across the Atlantic had reached its summit, and that he did not hope for any further elasticity.

The Chairman observed that he had qualified that remark by saying that any improvement in the state of trade might give them an increased traffic.

Mr. Chester believed that telegraghy across the Atlantic was still in its infancy, and that there was a very great expansion for it. They were now at the tail end of three years of the greatest depression that the financial world had ever seen, and he thought that when once they turned the corner (and he believed that it would be turned before long) they would see that telegraphy across the Atlantic would expand ve.y much more than they imagined at present. He was very sorry to hear that the result of the deliberations of the Board had led them to come to the conclusion that they would either possibly have to raise rates or fight. The Directors could not put their feet down on the expansion of the civilisation of the world, and if they thought they could stop telegraphic communication by fighting with other companies, the result would be as it had been hitherto. Every cable that had been laid they fought against and tried to cripple, and finally they had had to buy it up, and the result had been that another cable had been laid directly afterwards. They had been told that the renewal fund could not be used according to the Articles of Association, for any other purpose than that of a renewal fund. But he believed the articles would allow the Directors to enter into negotiations for the purchase of the last two cables which had been put down whenever they liked. If he were in error in that view he would be glad to be corrected. He thought the shareholders who spoke and voted at meetings should stay behind and record their votes when a poll was taken, which was not done on the last occasion. They had seen the determined stand which the Chairman had made with regard to the renewal fund. But what had they found? A body of gentleman had got dissatisfied, a small committee had been organised, they had got round them the nucleus of support, and the moment the Board saw an organised opposition to their policy, which had been so lauded, the Board had given in.

Mr Stockdale said he was very glad to be able to congratulate the Chairman on the striking contrast in the tone of the present meeting compared with that held for the last three half-years, and he thought the change might be attributed to the interview which the Board had courteously granted to the committee. He was pleased to be in a position to say that after a discussion of some two hours' duration by mutual concession they all arrived at a satisfactory understanding [A Voice: "We have heard all this"], and he trusted the shareholders would be satisfied with the result of the committee's alteration with respect to the renewal fund. With regard to that fund, they thought that the shareholders ought to have a voice in the control of such a large sum, for, as was stated by a very eminent legal gentleman at the former meeting, under the present Articles of Association the shareholders had no power whatever. In fact, he did not wish to say it in any offensive sense to the Board, but the Articles of Association virtually placed the shareholders in the category of infants or felons, inasmuch as these articles gave them no power or control over their property. He hoped the Board would see their way clear without being opposed and without any agitation to grant this very moderate concession to the shareholders, who, he was sure, would be only too ready to give the Board power to appropriate to proper purposes part or the whole of the renewal fund. That was what was done in all railway and large companies—the shareholders were first appealed to. He might state that if they had had to go to a poll the committee were prepared to offer very strong and substantial opposition by the amount of proxies which they had received.

Mr. Davison said that they had it on record that the Company required four cables to keep up its engagements with other companies. They also knew on very good authority that the life of a cable was from twenty to thirty years. They had it, moreover, on the authority of their excellent Chairman, that the cost of a cable was about £400,000, and it therefore required very little calculation to see that they would want to renew a cable every 7½ years on the average. Very little consideration would show that the sum of £44,000 per annum, with the increment of compound interest, would produce a sufficient sum to provide £400,000 every 7½ years. They had hitherto put aside something like £180,000 per annum to the renewal fund. The permanent increment of that fund was now stopped, and they would observe that if it were fairly invested it would realise a sum beyond what he had stated. They might fairly assume

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that the renewal fund, if properly invested, would realise about £50,000 per annum.

The CHAIRMAN: That is at 5 per cent.

Mr. DAVISON thought they would therefore see that if the renewal fund were now stopped at a million and interest on that sum were added, with possibly a slight contribution from revenue if necessary, it would be ample to keep up the cables in future. He congratulated the Directors and the Chairman on having come to the decision which had been indicated.

Mr. JOHN NEWTON said he would not trouble the meeting with improper statistics based on erroneous assumptions as the last speaker had. With regard to the life of a cable, the cables which were now being laid were altogether different from those which had originally been put down, and their life could not be estimated. At a former meeting the Chairman of another company had said ten years ago that the life of a cable was ten years. But those cables were still going on working efficiently. The cost of a cable was not £400,000, but a good deal more. [The CHAIRMAN: Hear, hear.] From Ireland to Newfoundland perhaps a cable could be laid for £400,000, if the manufacturer made no profit out of it. He, however, rose mainly to thank Mr. Smith and the members of the committee for what they had done. They had established this fact, that notwithstanding the abominable system of proxies, the shareholders had some power, and if they could indicate wise and sensible views as to the manner in which their property should be conducted, those views would prevail, notwithstanding that the Directors had their Articles of Association, and could fortify themselves by taking the opinion of eminent counsel, who, of course, would tell them that what they wanted to do they could do in the manner in which the case would be submitted. Those articles, he contended, required alteration, for they were most unfair to the shareholders.

Mr. JACKSON desired to support entirely the remarks of Mr. Smith upon the adoption of the report. He wished first, however, to draw attention to, and acknowledge the benefit which the Company had derived from the exertions of their able general manager at the last International Telegraph Convention at Berlin. The result of these international conferences might be a very serious matter to the Cable Companies, and Mr. Pender, at the late meeting of the Eastern Company, pointed out that that company, by the action of the last Conference, had had to submit to a sacrifice oi £40,000 a year. No such action, however, had been taken in the case ef the Atlantic cables, and he thought they were very much indebted to the Board for obtaining that important concession. For the next five years they would have an opportunity of developing whatever traffic there might be in the Atlantic. He was glad to hear Mr. Chester's remarks with regard to the question of the elasticity of that traffic. Someone had said that the committee ought to be remunerated out of the funds of the Company, but he did not think that that ought to be done. Moreover, the committee had not yet done their work. The question that any expenditure of their vast renewal fund should come before the general body of proprietors would not be dropped. With respect to the Articles of Association, they were drawn up by Mr. Burt for a company in a very different position—for a few capitalists who subscribed a very large amount; and he believed that the same able gentleman would, if he had instructions, be able to carry out such alterations in the articles as would meet the reasonable views of the shareholders.

Mr. PARKER said that the Chairman had referred to the renewal fund as forming a backbone, and he had evidently used the expression not merely as indicating the fact that the possession of that fund would enable them to renew their cables if necessary, but that it might be used also for competing with other companies. It seemed to him that there had been a practical admission that an alteration was required in the Articles of Association, and that the policy of the Board had been of a very doubtful character in buying off competition, as they had done in the past.

MR. GRIFFITH said that the case presented by the committee to the Directors was so strong that he thought the latter had acted wisely in conceding the point mentioned, which was certainly of great importance. He maintained that a million was more than enough for their necessities, and so far he agreed with the remarks of Mr. Davidson, that even if £45,000 were now put by by the accretions of interest, that that would be sufficient for their purpose. He thought that there was great force in the demand which had been made for altering the Articles of Association, and that it would be for the benefit of the Company if they had more unity in the future, and if the Board would allow that the shareholders ought to have a voice in the disposition of the renewal fund.

The CHAIRMAN, in reply, said that with regard to the investment of the renewal fund, it was not the fact, as one gentleman had appeared to suppose, that it was invested in the names of any of the Board. The securities were in the name of the Company, and could only be altered or changed by a resolution of the Board under the seal of the Company. A false construction had been put upon his remarks by Mr. Parker. That gentleman had talked of his having spoken of the renewal fund as the backbone of the Company in the event of a contest. He (the Chairman) had merely meant, when they had a renewal fund which could replace all their plant, that they could feel at perfect ease as to any income that might accrue in using it for competition. He never meant to imply that the renewal fund should be used directly in any contest; and he believed it would be a gross malversation if it were so used. Some observations had been made as to the cost of laying a cable. Mr. Weaver was appealed to, but he (the Chairman) did not think that what that gentleman said was perfectly heard by the meeting. The fact was, that the last cable laid cost the Company in money £430,000, but in addition to that they had the shore ends of the old cable to make use of, and very probably those shore ends, if they had had to replace them, would have brought the cost of the cable up to £500,000. That, therefore, was the cost of a cable according to the most recent experience they had had. Mr. Chester had asked what were the costs and what were the receipts for the whole year of the steamship "Minia." He had given them that information for the last half-year, but for the whole year the total cost of the vessel was £26,228. She was chartered by other companies during the year, and in that way earned £16,430, leaving a balance of £9,798, which represented the whole of the cost of the repairs during the year—he meant as far as the ship was concerned. For that balance they had done the whole of their repairs during the twelve months. There had been a great deal of discussion, but it had been all of such an amicable nature that he did not think it necessary for him to trouble the meeting with any further observations. He then put the motion, and it was carried unanimously.

On the motion of Sir DANIEL GOOCH, Bart., seconded by the Marquis of TWEEDDALE, Lord Monck was re-elected to his seat at the Board, as was also Mr. Wm. Barber on the motion of the CHAIRMAN, seconded by Sir DANIEL GOOCH.

Mr. SEELY proposed, and Mr. JACKSON seconded, the re-election of the auditors, Mr. Joshua Dean and Mr. Francis Glass.

Mr. NEWTON next proposed, and Mr. SEELY seconded, a vote of thanks to Mr. Thos. Smith for his exertions on behalf of the shareholders, Mr. Newton remarking that that gentleman was a very large holder of the stocks, and deserved the thanks of the shareholders for what he had done, as did also the members of the committee.

The CHAIRMAN put the motion, which was carried.

Mr. SMITH having briefly returned thanks for the compliment paid to him,

Mr. JACKSON proposed a vote of thanks to the Chairman and his colleagues.

Mr. GRIFFITH seconded the motion, which was carried, and

The CHAIRMAN having acknowledged the vote, the proceedings terminated.

Anglo-American Brush Electric Light Corporation (Limited).

The fifth ordinary general meeting of their Corporation was held at the Cannon-street Hotel on Wednesday, the 10th inst., under the presidency of Lord Thurlow.

The SECRETARY (Mr. Emile Garcke) read the notice calling the meeting.

The CHAIRMAN then moved the adoption of the report and accounts, and in the course of his remarks said: I desire to congratulate you, and congratulate you heartily, on the improved aspect of affairs which enables us to come before you to-day recommending, it is true a small, but an honestly earned dividend for the past year. I think that this is a source of congratulation, not on account of the amount of the dividend, whether it is large or small, but on account of the fact, as when Directors as a Board feel themselves justified in declaring a dividend, you may, as a rule, be pretty sure that the business of their company is on a satisfactory footing. I can assure you that the position that we have thus been restored to has not been attained without considerable anxiety both on the part of this Board and of the hard-working members of our staff. I may say that if we have attained that position it is mainly due, I think, to the strenuous exertions which have seconded our endeavours, and to the able assistance we have received from the gentlemen who compose our technical and permanent staff. In saying that there is one thing that I must not forget to add, and that is that I consider that the fact of our having returned to a dividend-paying position is due in the first place and in the last place to the unremitting confidence with which we have been treated by our shareholders. You now have had the patience to put your faith in us without receiving any rewards for the past three years, and I assure you I feel very much, as far as I am concerned, that we owe you a hearty vote of thanks for the confidence you have shown in us, without which it would have been perfectly impossible for us to have carried on. The result is that we have turned the corner, and that the affairs of the Corporation now rest not only on a satisfactory, but I believe on a very strong foundation. The works in Belvedere-road have been fully employed with the execution of good orders during the whole of the past year. The volume of work that we have executed during 1885 exceeded that which we did during 1884 by about 25 per cent. The net profits bear as nearly as possible the same relation to each other—those earned in 1885 and those earned in 1884—and those earned in 1885 would have been very much larger had it not been for, I may say, the extravagance of our predecessors, and the fact of our being hampered with an establishment and with premises that are still far beyond our manufacturing requirements. This is an evil which is being remedied, and which can only be remedied in the present by the increasing volume of business, for we have considered the matter from every point of view, and we do not see how we can either profitably reduce our expenses or our establishment in the face of the business which is now growing up. I should add that we have on hand a large number of genuine, sound, and paying orders, which we are now executing, and which will carry us on for almost the whole of the twelve months without any other order. These orders are received from the Government for various colonial departments, for manufacturing firms in England, and for lighting the impending exhibitions which are going to be held in London, Liverpool, Edinburgh, and I think I may add in Folkestone. This is so far a highly satisfactory state of things; but I assure you that we are not contented, and we are doing our utmost from day to day to acquire more orders. But there is this satisfactory feature about our position, and it is a feature which has never changed during the past year, that these orders do come in with regularity. Whether they come in from one quarter or another they come surely enough, and our

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establishment, of on the average 300 men, has been fully employed, and often employed on overtime during the past year. I desire also to take this opportunity of tendering my thanks to those 300 men for the very great intelligence, energy, and zeal which they have displayed in our service. They have worked for us without a murmur at overtime, frequently on holidays, bank holidays, and others, and during the past year we have not had a single complaint of any serious character against any one of our members. I do not propose to enlarge on the accounts, but there is one little item there that I do desire to refer to—it is the cash at the bank. It appears in the balance-sheet at £6,593. That, of course, is a statement which represents our actual cash balance at the 31st December last, after all our transrctions were squared up. But I desire to assure you that that is not all the capital that we have got to come upon. Far from it. We have, as you will see in another place, £33,000 of good debts owing to us from our various customers, against £20,000 or so due to us at this time last year. That alone shows an improvement of more than 50 per cent. Then our debts are on a moderate scale, they are slightly in excess of what they were last year, but not more so than is fairly represented by the increased volume of business and the necessity of our having a large supply of materials on hand. You are all aware that from time to to time in the newspapers you see that your shares have fluctuated. They have gone down or up. There is absolutely no reason for these fluctuations, and that is one of the reasons why they are one of the greatest trials that a Board like this has to deal with. They encourage false hopes, and they create false despondency. People who have perhaps nothing else to guide them by see the shares go down and sell without rhyme or reason, whereas these fluctuations, as you here all know, are the result of certain clever manipulations of people acting for their own ends. They, however, bear no relation to the state of things that exists at the time. Remember that your shares are worth the money at which they now stand at par, and if you take my advice never part with them for less. There is another matter in this report which is eminently satisfactory, viz., that the public installations that we have run during the past year have been a source of profit and not a source of loss, as in preceding years. These installations, as you know, are at Charing Cross, what is called the City circuit, some lighting we have undertaken at Bristol and Cardiff, and also at Manchester, and one or two other small installations. In 1883 these installations caused us a debit altogether in our accounts of £642. In 1884 they caused us a loss of £268, but this year we have actually derived from them a net profit, which I will not exactly name as these accounts are not all finally closed, but it is a respectable profit, which may be written in three good figures. That, I think, is a matter for congratulation. There is one other point of importance to us all about which I desire to take you into the full confidence of the Board. He then referred to the Bill promoted by the South Eastern Railway Company for an extension of their line, so designed as to cut off a portion of the Company's works, at which point the South Eastern Railway Company propose to widen their line. This, his lordship explained, would involve a considerable sacrifice on the part of the Company, and entitle them to considerable and substantial compensation, for even if what remain of their works would meet with their requirements, they would have to remodel the office, and be put to heavy loss and expenditure of he did not know how many pounds. They had protested against that conduct on the part of the railway company, and from time to time had filed petitions in Parliament, and they were about to do so again, as the railway company had applied for a further extension of time, during which to hold this sword over the heads of the shareholders. The railway company were playing a waiting game, but it would be unfortunate for them, as the company was now paying a dividend, a position which would obtain for them greater indemnification; so that so far nothing had been lost by the time that had elapsed. Continuing, he said: There is another point of very great importance touched on briefly in the report. It is what is called the City lighting. For over a year—I think for nearly two years—we have been in communication with the authorities in the City for arranging a considerable circuit of electric lighting. That has been a very complicated matter, but I hope that the negotiations are now approaching a satisfactory termination. Still, it is a subject of considerable anxiety and importance, because the moment this contract is signed we shall have to find a very large sum of money—a heavy capital sum for laying down these mains and preparing to execute this traffic. We shall have to find the money, and we shall have no difficulty when the time comes in doing so. But I desire to assure you with respect to this matter that we are not rushing into it blindfold, and that we shall only agree to it on three conditions. First, that it is on a paying basis as regards price; second, that it is for a term of years of some duration; and third, that we are to have the right of laying mains of sufficient size to supply customers on both sides, and that the mains are to remain continuous even should the City lighting contract be interrupted. This matter is still under consideration, and is receiving our close attention. Next in order of important subjects comes our foreign business. You are aware that the Continent is more favourably situated as regards electric lighting and all matters concerning electricity than we are. They have no Electric Lighting Act of 1882. They have no repressive legislation, but they are only subject to the common laws of the land. We have been doing a considerable business in Germany for the last eighteen months. About that time a Mr. Plewe came over here with excellent recommendations to us. We entered into communication with him and made a contract with him to supply him at certain rates. We have supplied him ever since with very large numbers of dynamos and large quantities of electrical apparatus, and he has given payment in bills for very large sums which have been met to the day. I am bound to say that the conduct we have met with from Mr. Plewe and the syndicate of bankers who have associated themselves with him in Berlin has been of the most satisfactory character to us. Last autumn they approached us again. They desired to enter into still closer relations with us and to enter into still more extensive business. The proposals they made were so important that it was deemed advisable that Mr. Wynne, the then general manager, and I should go over to Berlin and make further inquiries. We went over to Berlin, and we were received with the utmost courtesy by those gentlemen. They explained the great scheme they had, which I am bound to say seemed to be fully participated in by the public. I made inquiries from eminent banking houses there, and found that there was no difficulty in getting capital to any extent in Berlin for electric lighting. The result of the inquiries I made and the negotiations we conducted were eminently gratifying, and ended in the signing of a sort of treaty by which we have in the first place undertaken to establish the plant for a central lighting station in one of the most commercial and busy quarters of the town of Berlin. This is now being carried out, and I have no doubt it will be the forerunner of very large schemes of lighting, not only in Berlin, but in Dresden, Hamburg, and in other places in which this energetic Mr. Plewe and the syndicate of bankers are preparing the ground for us. It is curious to see on the Continent how differently matters connected with electricity are regarded from what they are in this country. There they are looked upon no longer as being in the initiatory stage, but as having attained to something like perfection. People are no longer hesitating about going in for electric lighting, but are doing that, and demanding electric power besides. People in London would hardly credit the march of electrical science in Berlin. The tramcars there even are already constantly run by means of electricity, and there is now a company formed to take over the whole of the tramcars in Berlin, to abolish horses, and run them with electrical motors at a profit of about fourfold of what the companies are making with horses, and charging at the same time about half the fares which are now being charged. I now come to the troublesome matter of amending the Electrical Act of 1882, of which we have had quite enough. You, perhaps, will remember the steps we took in that direction in the autumn of last year—even the summer of last year. We formed, with other gentlemen interested in this science, a very powerful committee. We were fortunate in obtaining the cooperation of the most distinguished men, like Sir William Thomson, Sir Frederick Abel, Sir Frederick Bramwell (who has rendered us the greatest assistance), Prof. Silvanus Thompson, Prof. Ayrton, Viscount Anson, Mr. Forbes, and a dozen more, and we met from time to time in your office at Belvedere-road, and with the assistance of high legal authorities, who gave us the benefit of their advice and professional knowledge with the utmost courtesy, and without any remuneration, we drafted a Bill to amend the Electric Lighting Act of 1882. That Bill was to have been brought before Parliament by one of us, but it appeared afterwards better to have it introduced into Parliament by some gentleman who was above suspicion as being unconnected with electric lighting, or the electrical industry whatever. Sir Frederick Bramwell here again came to our assistance, and he succeeded, I am bound to say without much difficulty, and I rejoice at the fact, in obtaining a promise from Lord Rayleigh, who ranks second to none in scientific knowledge in England, and I think in the world. He has kindly undertaken to introduce our Bill, or a Bill based on its provisions and identically the same. He is only waiting now till Parliament meets on the 18th or 20th of this month to introduce it. The broad principles on which that Bill proceeds are simply to place electric lighting on the same footing as gas. To effect that, there are really only two clauses of that Bill of 1882 which will need repeal. The first is what is known as the lamp clause—Clause 18, I think—under which the undertakers are prohibited from prescribing the form of lamp to be used in connection with an installation. In the absence of any correct meter, it is imperative to grant us that condition, for how can we tell but what the persons using the electric light might use lamps which would consume more electricity than they had contracted to pay for? Moreover, we have the excellent precedent before us of the Gas Works Clauses Act of 1845, when gas was in its infancy, and Clauses 18 to 20 in that Act gave the power to gas companies in the absence of a meter to prescribe the form of lamp which should be used. That we should be entitled to do the same is an act of fairness which Parliament will not refuse. Then there is another famous clause, No. 27 of the Act of 1882. As that one is sufficiently known I need not dilate upon it. It enables a local authority to buy out an undertaking for the supply of electricity at the expiration of 21 years practically at the price of old iron, and without taking into calculation either the profit, the goodwill, or any conditions which enter so largely into the value of a property. It is not too much to say that Clause 27 as it stands is perfectly prohibitory of electric lighting, for who will subscribe capital when they know of the existence of this clause? And even if you got the capital subscribed, how could you get the customers to pay such a prohibitive rate as would be necessary to recoup the promoters in 21 years? I have no doubt that that clause will be found cut out in the Bill that will pass Parliament. The late Government that has just gone out of office had proposed to deal with this question. Mr. Stanhope, who was President of the Board of Trade (I heard this unofficially), had proposed to bring in a Bill to prolong the period from 21 years, I am informed, to 40 years. No doubt half a loaf is better than no bread, and we should rather have it 40 than 21 years. But as the gas industry was never subjected to any of these restrictive measures at the outset, why should we? And arguing on that basis I protest that any limitation of the kind is an injury and an injustice. I have no doubt that the Bill, as drafted now by us and as submitted to Parliament by Lord Rayleigh, will shortly be introduced; and as I have said before, the justice of Parliament will insist on its being the law of the land. His lordship then referred to the number of unemployed men who were anxious to work, and ventured to say that no more easy and no more efficient relief works could be supplied than by simply amending the Act of 1882, as it would open the door to the immediate establishment of a new and a very extensive industry, involving the lifting of every street in London to lay the elec-

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trical mains from which every house in London would in due course demand to be supplied. There was abundance of capital waiting to be invested, which would only be too readily embarked in the enterprise. He regretted that since the last meeting Mr. Ladd, one of the Directors, had died. They had also lost the services of Mr. Courtenay, from whom they had received constant and valuable assistance, and that gentleman had only left them because he had to devote himself to another branch of electrical science, the Storage Company, which of late had been making such giant strides as to call for more continual labour from its managing director, a position held by Mr. Courtenay. To fill the vacant seats two gentlemen had been elected who were most favourably known in connection with electrical science—Lord Sudeley and Major-General Webber of the Royal Engineers. These gentlemen were rendering the Company most valuable assistance. Major-General Webber had placed them under a further obligation by accepting the office of managing director, an appointment which had become necessary by the resolution the Board had arrived at to have the services of Mr. Wynne henceforth exclusively devoted to superintending the foreign business of the Company, a position for which that gentleman was well qualified, owing to his long residence abroad, and his intimate acquaintance with foreign languages. He concluded by moving the resolution.

The VICE-CHAIRMAN (Mr. J. S. Sellon): The explicit manner in which Lord Thurlow has referred to the present position and prospects of the Corporation, as well as to the other matters of general interest in connection with the important undertaking in which we are engaged, necessitates but few words from me in seconding this resolution. On former occasions I have had the honour of pointing out to you that by virtue of its patents and the vast field of work which can be covered by its manufactures, the Corporation had an exceptional position. Whatever class of work is needed—I would rather say whatever class of machine is required—whether for high or low tension, whether for isolated and closely localised installations, or for work extending over a distance of many miles, whether for motive power or electro-chemical purposes, the patents you possess are without doubt the most comprehensive, and the apparatus which can be manufactured under them the most nearly approaching perfection of any known system. This being so, you may perhaps ask why more speedy progress has not been made in securing a practical result from this possession—a practical result of earning large dividends. Well, gentlemen, Rome was not built in a day, and the development of a new industry of such a nature cannot, and possibly had better not, be too rapid. Solid foundations are needed for good and durable work, and in the case of this special and as yet little known branch of practical science public confidence has to be won, the prejudice and opposition of vested interests have to be contended against, and the adaptability and advantages of any such new departure have to be still proved. I believe I am right in saying that nearly seventeen years elapsed after the introduction of gas before any gas undertaking was a financial success. I do not think we need anticipate 17 years in the case of electric lighting, for events move more quickly in these days; and though the electric light starts with gas in full possession of the field against it, and surrounded by difficulties which I believe surrounded but few industries, yet I think if we take seven instead of 17 years as the necessary probationary period for electricity to prove its superiority over its great rival, we should not be far from the mark. Nearly six years have now elapsed since it may be considered the first street was electrically lighted, and I may incidentally mention that to this Company belongs the credit of having been the pioneer of electric lighting. As the Chairman mentioned, the authorities of the City of London have, we hope with wise consideration, shown signs of giving in this direction the encouragement and facilities which lie within their power despite any Electric Lighting Act. They have, perhaps, realised, as have our American cousins, that a well-lighted city is a well-policed city. In the towns of the United States the question of any apparent excess in price has been quite subordinated to the advantages of the increased light, and to the indirect economies they have obtained by it, and few who know anything of the matter can doubt that the extension of the electric light must come about. On this subject I would recall to your mind the words which were spoken at one of our meetings by Mr. Sutherland, the well-known managing director of the Peninsular and Oriental Company. These are the words of that gentleman, whose judgment and sound commercial views bear great weight:—"The other fact to which I would call your attention is the most important of all, and it is this, that the progress of electric lighting is as absolutely certain and sure as anything can possibly be. It may be delayed; it may be hampered; it may be opposed by the great industry of gas, and by quarrels among the proprietors in electric lighting companies; but I think none of us who have eyes to observe can fail to see, day by day and year by year, that the progress of electric lighting is becoming more general and more real." In conclusion, he endorsed the remarks of the Chairman as to the valuable acquisition to the Board in the persons of Lord Sudeley and Major-General Webber.

The CHAIRMAN put the motion, which was carried unanimously.

Mr. H C. GIBBS proposed, and the Hon. Mr. SAUMAREZ seconded, the re-election of the retiring directors, Lord Thurlow, Mr. Sellon, and Colonel Steuart, which was unanimously agreed to. The auditors, Messrs. Cooper Bros. and Co. were afterwards reappointed.

On the motion of Mr. P. COPLAND, a vote of thanks was passed to the Chairman and Directors.

The CHAIRMAN, in reply, said that he had made a calculation, and he desired to mention it in connection with the subject of relief works. By the amendment of the Act of 1882, he estimated that work could be provided for over three years for more than 10,000 men, at an expenditure of six millions sterling. That would be to do the necessary work in London alone, apart from Liverpool, Manchester, Birmingham, and all the great cities of the country.

The proceedings then terminated.

The Telephone Company of Austria (Limited).

The adjourned second ordinary general meeting of this Company was held at the Company's Offices, 34, Walbrook, on Tuesday last, under the presidency of Mr. Henry Gröwing.

The SECRETARY (Mr. R. Rodgers) read the notice convening the meeting and the minutes of the last meeting, which were confirmed. The report and statement of accounts were taken as read.

The CHAIRMAN, in moving their adoption, said that since the last meeting, which was purely of a formal character, the accounts, which at that time were not ready to be submitted to the shareholders, had to be re-arranged in accordance with the requirements of the law of Austria, which was rather stringent on the point; but after a good deal of correspondence they were approved and passed by the office in London. The results of the Company's operations, as set forth in the balance-sheet, were very satisfactory, considering that they had had to deal with the worst period of the Company's history. The increase both in the number of subscribers and in the revenue continued to advance steadily, and they had every reason to believe that the next report would prove the correctness of their anticipations of future prosperity. The only drawback that they had to contend with at this time of the year was the very severe snowstorms which always occurred in that part of Europe; but he was pleased to say that very little damage had been done to their plant during the present winter months, and their Exchange communications had been almost uninterrupted. This, no doubt, was in a great measure attributable to the solid way in which their telephonic system was constructed, for which he took the present opportunity of complimenting their general manager in Vienna, for whose efficiency and industry the most hearty acknowledgments of the shareholders were due. In consequence of the requirements of the Austrian law which, as he had said, was somewhat exacting, they had been obliged to alter the date of their financial year, which, up to this time, ended with the ordinary year, but which, in future, would date from the 31st March of one year to the same date of the following year. He might say, in conclusion, that the Company's relations with the authorities in Austria, both Governmental and Municipal, were of the most satisfactory character, which was a good augury for the future prosperity of the Company.

Mr. C. L. W. FITZGERALD seconded the motion, which was carried unanimously.

Subsequently, Mr. Gröwing, who retired by rotation from the Directorate, was re-elected, as were also the auditors, Messrs. Deloitte, Dever, Griffiths, and Co., and a vote of thanks having been accorded to the Chairman, the proceedings terminated.

Submarine Telegraph Company.

Report of the Directors to be presented to the meeting of the proprietors, to be held at the Offices of the Company, 2, Throgmorton-avenue, London-wall, E.C., on Tuesday, 16th inst., at one o'clock:—

The receipts for the six months ending 31st December, 1885, amounted to £64,782. 0s. 4½d., being £456. 19s. 11d. more than in the corresponding six months of the year 1884, while the expenses have been less by the sum of £75. 2s. 4d. The net result of the business for the six months enables the Directors to add £8,083. 0s. 10d., the usual proportion of the gross receipts, to the reserve fund, and to recommend a dividend at the rate of 14½ per cent. per annum, leaving a balance of £414. 3s. to be carried to the next account. For the corresponding period of 1884 the dividend was 14 per per cent., and the balance carried over £377. 18s. The receipts from the ordinary traffic for the six months were somewhat less than in 1884, although there were 62,351 more messages transmitted, but the average length of those messages was only 11·44 words, against 11·91 in 1884. There has been also a falling off in the receipts in respect to the messages transmitted, by the Eastern Company over the wire leased to that company, partly by reason of the reduction in the inland rate of telegrams on the 1st October last. But, on the other hand, there has been an increase in the special receipts from the fresh arrangement made with the Indo-European Company, referred to in the last report, and from an agreement recently entered into with the Commercial Cable Company for the use of a special wire to Havre for the transmission of their French-American messages. The Company's cables, as well as those under the care of the Company, have, with two exceptions, been worked during the half-year without any interruption. The exceptions are the Dieppe cable and the cable between Salcombe and Brest; the former was broken on the 14th and repaired on the 22nd December, and the latter was broken on the 25th October and repaired on the 14th December, 1885. In the last report it was stated that the cables during the first six months of the year were also remarkably free from interruption; consequently, the repairing ship was in port for many months. The drawback paid by the insurance company at the expiration of the yearly policy in August was £486, or £160. 10s. more than the charge for insurance for the six months ending December, 1885. This is the reason for the absence of the usual charge in the accounts under the head of "Insurance of Steamer." The sum of £160. 10s. will, moreover, be credited to revenue in the next accounts. An International Telegraph Conference was held at Berlin in August, when the Company was most efficiently represented by Mr. George de Bunsen. The result of the Conference was that some of the telegraph charges were reduced, but the slight modification in the rates between this country and the Continent of Europe will not, it is expected, prejudicially affect the Company's revenue. The new rates do not, however, come into operation until 1st July, 1886. All the Company's cables, as well as those worked by the Company, are at the present time in good working order.

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The India Rubber, Gutta Percha, and Telegraph Works Company.

Report of the Directors for the year ending December 31st last, to be presented at the twenty-second ordinary general meeting of the shareholders, to be held at the Cannon-street Hotel, on Thursday, the 18th instant, at 12 o'clock noon.

From the accounts it will be seen that the net profit for the past year amounts to £65,662. Adding £40,070. 13s. 3d. brought forward and £52,393. 15s. premium on new shares issued, and deducting £20,779 interim dividend paid in July, there remains a disposable balance of £137,547. 8s. 3d. The Directors have added to the reserve fund £55,000 (which includes the premium on the issue of new shares), and recommend the distribution of a dividend of £1 per share, free of income-tax, amounting to £41,600, making, with the interim dividend, a total payment for the year of 15 per cent., and leaving £40,947. 8s. 3d. to be carried forward. In general sales and in cable work the amount of business done has been up to the average of the last few years. Cables have been manufactured and laid connecting the Cape Verde Islands with the West Coast of Africa, and have been sold to the Eastern and Brazilian Submarine Telegraph companies. Coast cables connecting the Portuguese and French possessions in Western Africa are in course of manufacture, to be laid under a guarantee of traffic from Portugal and an annual subsidy from France. About 600 miles are already laid, and the whole line is to be completed during the present year, and worked by the West African Telegraph Company (Limited). Besides other cable work, 530 miles were manufactured for the Government Indo-European Telegraph Department, and carried out to the Persian Gulf in, and laid from the Company's vessels. The Company's share of the work has been handsomely acknowledged by Sir J. U. Bateman-Champain, K.C.M.G., director-in-chief, in his report to the India Office, recently published. The death of Mr. George Henderson, which occured towards the close of the year, is keenly felt by his colleagues. For more than twenty years he had, as Director and Chairman, given unwearied attention to the Company's interests, often, in times less prosperous than the present, making himself personally liable on its behalf. His health had been failing for some time before his death, but almost to the last the Board had the benefit of his sober judgment and great experience. The Board have appointed Mr. Gray a Director in Mr. Henderson's place, and it is intended that he shall become Managing Director. With a view to this, and to further strengthening of the Board, special resolutions will be submitted to an extraordinary general meeting of shareholders, to be held immediately after the ordinary general meeting. The last of these special resolutions refers to the Company's French works. The Directors bear in mind the possibility that such a sale may be advantageously made sooner or later, and desire to have power to act if the opportunity should occur. Mr. Silver and Mr. Bannatyne, the Directors retiring by rotation, offer themselves for re-election.

The Phosphor-Bronze Company (Limited).

Report of the Directors, to be submitted at the twelfth annual general meeting, to be held at the offices of the Company, on Friday, the 19th inst., at 12 o'clock :—

As will be seen from the accounts the net profits amount to £3,216. 17s., after writing off the whole of the investment in Osborne and Co. (Limited), amounting to £500, £482. 12s. 7d. for depreciation of property, and £391. 18s. 11d. for bad and doubtful debts. Out of this sum your Directors recommend a dividend of 4 per cent. per annum, free of income-tax, which will absorb £2,882. 9s. 7d., and leave £334. 7s. 5d. to be carried to the reserve fund, in liquidation of the debenture liability. The dividend of 4 per cent. will be paid on 27th February next, should the Directors' recommendation be adopted. There has been a slight falling off in the sales of the past year as compared with those of 1884, which, considering the state of trade and the continually increasing competition, is not to be wondered at. The investment of £2,000 in the Sociète Lazare, Weiller and Co. will produce a dividend of 5 per cent. per annum, and profit and loss account has therefore been credited with £100. This, society intends placing a considerable sum to reserve, so that this investment will increase in value. The fact of Messrs. Lazare, Weiller and Co. having done a large trade in wire is also encouraging, as it proves the value of the new silicium-bronze telegraph and telephone wire, for which this Company holds the patents for the United Kingdom, India, the British Colonies and dependencies. The sales of wire, rods, tubes, sheet, and other articles produced by the mills in Birmingham have been larger in the past year than in 1884 ; but, unfortunately, owing to the great depression in trade, many of the Company's Birmingham tenants have left without paying overdue rents, so that now, instead of obtaining £400 per annum for steam power, as formerly, only about £200 per annum are being paid. Over £163 for rents due in 1884, which were regarded as an asset in the last balance-sheet, have been deducted from this year's accounts owing to the utter inability of the tenants, through want of work, to pay anything. It must not be overlooked that the mills, by producing wire, rods, tubes, sheet, and other finished goods, enable the Company to extend the area of its operations, and it requires but a very small extension in the trade of these articles to make the mills highly remunerative ; but in order to meet the requirements of the day constant additions to the plant are necessary. The mills and the old machinery therein, being kept in a good state of repair and preservation, and the expenses connected therewith being debited to revenue, your Directors do not think it necessary to write off this year any sum for depreciation thereon. In the cost of production of the Company's goods at the foundry considerable economy has been effected ; but as the advertising account has always been a very heavy and constantly increasing item of expenditure, your Directors have determined to make a large reduction whilst trade is so depressed. This reduction will be apparent in the next year's accounts. The torpedo boat is now completed, but the unfavourable weather has hitherto precluded any trial ; meanwhile, negotiations are pending for her sale. The legal proceedings in connection with the building of this boat have ended satisfactorily, and at a comparatively trifling cost to the Company. The French Government have, it appears, lately ordered two bronze torpedo boats, which circumstance appears to point to the ultimate adoption of bronze for the hulls of these vessels. In order to secure a return to the Company of some of the Liverpool business, and to execute local orders more promptly, your Directors have, at a small cost, established a branch foundry there, which they anticipate will prove a profitable venture when the trade in that great shipping port begins to revive. This foundry practically pays its expenses already, and will be the means of securing local orders for castings, which would otherwise not be sent to the Company's London foundry. The Company now make and sell gunmetal, brass, and other alloys of a similar character, in the manufacture of which no extra expense is incurred, and as its travellers are enabled to take orders from consumers of metals who will not, or cannot, use the more expensive alloys of phosphor-bronze, it is hoped that the Company will soon have a much larger volume of trade. Since the ciricular issued on the 17th July, 1885, Vice-Admiral Sir J. Edmund Commerell, V.C., K.C.B., M.P., has joined the Board, and Mr. J. W. Bushby has just resigned the chairmanship in his favour, but remains a Director. One director (Sir J. E. Commerell) retires at this meeting, under the Articles of Association, and, being eligible, offers himself for re-election. Mr. James Rock has given due notice of his wish to become a Director again, having, your Directors are happy to say, been completely restored to health. The accounts have been audited by Mr. R. Payne, F.C.A. (Messrs. Payne and Henry, chartered accountants,), and Mr. R. Peters, the duly appointed auditors of the Company, who offer themselves for re-election.

BUSINESS NOTICE.—Messrs. Woodhouse and Rawson have been appointed by Mr. A. P. Trotter special agents in Great Britain and the Colonies, and sole agents on the Continent, for the sale of his patent dioptric glass.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Feb. 10.		Business Done Week Ending Feb. 10. Highest.	Lowest.
Anglo-American	32,	33	32½	32
Do. Preferred	55,	56	56	54½
Do. Deferred	9½,	10½	9¾	9 9-16
Brazilian Submarine	10⅞,	11½	11	10 5-16
Cuba	10¼,	10¾	10¾	10⅝
Do. Preference	17½,	18½	17¾	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	11¾	11
Direct United States Cable	9⅛,	9⅜	9⅜	9⅛
Eastern Telegraph	11⅝,	11⅞	11 15-16	11 11-16
Do. 6 per Cent. Preference	13¾,	14	14	13¾
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	12¾,	13	13	12⅝
German Union	9½,	10	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 1-16	6⅞
Do. Preference	13⅝,	15⅜	13⅝	13 7-16
Great Northern	14½,	15	14¾	—
Indo-European	33,	34	34	33½
Reuter's	7,	7½	—	—
Submarine	205,	215	—	—
West India and Panama	⅝,	⅞	—	—
Do. 1st Preference	8½,	9	8¾	8½
Western Brazilian	6¾,	7	6 15-16	6 13-16
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Companies.	Closing Prices. Feb. 10.		Highest.	Lowest.
Consolid. Telepho e and Maintenance	15-16,	1 1-16	—	—
Oriental	3-16,	5-16	—	—
United Telephone	11¾,	12¼	12¾	11 15-16

ELECTRIC LIGHT.

Companies.	Closing Prices. Feb. 10.		Highest.	Lowest.
Anglo-American Brush Light (£7 paid)	3,	3½	3 1-16	2⅞
Do. (fully paid)	4¾,	5¼	5	4⅝
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1½,	1¾	1¾	1 11-16
Maxim-Weston	5-16,	7-16	⅜	—

MISCELLANEOUS.

Companies.	Closing Prices. Feb. 10.		Highest.	Lowest.
Telegraph Construction	37½,	38½	38	37½
India Rubber, Gutta Percha, and Telegraph Works	24,	25	24¾	24½

TRAFFIC RECEIPTS FOR JANUARY, 1886.

Companies.	Jan., 1886.	Jan., 1885.	Increase.	Decrease.
Cuba Submarine	2,850	3,013	—	163
Direct Spanish Telegraph	1,686	1,756	—	70
Eastern Extension	39,699	44,144	—	4,445
West Coast of America	3,200	—	—	—

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NOTES.

Texas.—San Angelo, Texas, is considering a proposition for the establishment of an electric plant.

At the Cafe de Paris, Paris.—The electric light is now being installed in this café. The dynamo is driven by a compressed air motor.

The Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 12th inst. amounted to £3,399.

The Telephone in the United States.—It is said that there are three times as many telephones in the United States as in the whole of Europe.

Lecture.—To-morrow, at Sarbonne, M. Pillat, lecturer to the Faculté des Sciences, will discourse upon "Electrical Machines, Ancient and Modern."

Obituary.—The death has been announced of M. Jules Jamin, permanent secretary of the Académie des Sciences, and Professor of the Ecole Polytechnique.

The West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half month ended 15th inst. are £2,551, as compared with £2,339 in the corresponding period of 1885.

Underground Wires in Paris.—There are now about 461 miles of telegraph and telephone wires laid in the sewers of Paris. The Government is making new regulations with a view to decreasing the tax upon lines so laid.

Where is It?—In reply to our note under the above heading in last week's issue we have been inundated with assurances that Blackpool and not Blackwall is the place in question. We thank our correspondents for the information.

The New Postmaster General.—As the present Postmaster-General sits in the House of Lords, business relating to the Post Office in the House of Commons will be attended to by Mr. H. H. Fowler, the Financial Secretary to the Treasury.

Bulgaria and Eastern Roumelia. — The public are informed that telegrams for Servia, Bulgaria, and Eastern Roumelia are now accepted under the ordinary conditions, and not at sender's risk, which has been the rule since last November.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended 12th inst. were £2,646, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

A New Current Indicator.—A "new" current indicator is described in the present issue of the *Electrical World* as being the invention of Mr. Streeter, of Chicago. We fail, however, to see in what way it differs from the ammeter of M. Lalande described in these columns some months ago.

The New Post Office in Belfast.—Workmen are now being employed in laying the underground wires in Rosemary-street to the new Post Office in Royal-avenue. They were also engaged in attaching them to the wooden structure on the roof of the building. Business, it is expected, will be commenced next month.

Town Lighting.—It is proposed to electrically light St. Tropez, a small and picturesque seaport town, in the department of the Var and the arrondissement of Draguignan, on the shore of the Bay of Grimaud, thirty-eight miles E.N.E. of Toulon. The municipality, it is said, is asking for proposals from different electric lighting companies.

A Telephone Service between Paris and Brussels.—It is announced that telephonic communication is to be established between Paris and Lille, on the Van Rysselburghe system. The projected line between Paris and Brussels may therefore be put into practical effect before long. The two Governments, it is said, are at present considering the matter.

The Telephone in Portugal.—According to recent advices from Portugal the telephone exchanges at Lisbon and Oporto had at the end of October last 329 and 232 subscribers respectively. The Edison-Gower Bell Telephone Company, of Europe, had installed 168 lines in Lisbon and 97 in Oporto; there being a total of 826 telephones in service in the country.

Academie des Sciences.—At the last meeting of this Society M. Lippman was elected, by 31 votes as against 20 for M. Henri Becquerel, to the vacancy in the physical section formerly filled by M. Desains. Among the papers recently read before this Society was one by M. Trouvé, in which he detailed the results obtained by the method of Electro-Polyscopy, of which he is the inventor.

A Hot Dispute!—A French contemporary, commenting upon the claims of M. Marcel Deprez to the invention of the transmission of force by electricity, suggests that while this is questionable M. Deprez has an undoubted right to priority of invention in the matter of the transmission of *heat* by electricity. His method of burning up a distant motor is at once effective and unique.

Electricity and Mines.—The mines of Meurchin, Pas-de-Calais, have received an installation of arc and incandescent lamps, variously arranged. This has been put down by Messrs. Sautter, Lemonnier, and Co., and comprises 11 arc lamps of about 1,000 candle-power, and the same number of incandescents The mines of Blanzy, Saône-et-Loire, have also received a similar installation.

The Patent Laws.—The President of the Board of Trade (Mr. Mundella) has reappointed the committee instituted by his predecessor, to inquire into the working of the Patent Laws, and has requested Baron H. DeWorms, M.P., to continue to act as chairman. Sir R. Webster, Q.C., M.P., will take the place of the Lord Chancellor, and Mr. Acland, the present Parliamentary Secretary to the Board of Trade, and Sir Bernard Samuelson, Bart., will be added to the Committee.

Electricity for Cutting Coal.—An American paper mentions the fact that "Electricity has been employed to cut coal in some of the mines in Illinois, because it would not hold mass meetings and strike for higher wages." The cutting is described as done by a chisel at the end of a steel bar, fastened to a piston of soft iron in the middle of a cylindrical coil of insulated wire, and the desired reciprocating motion is given to the rod by reversing the current in the coils.

Society of Telegraph-Engineers and Electricians.—A meeting of this society will be held at the Institution of Civil Engineers, 25, Great George-street, Westminster, S.W., on Thursday, Feb. 25. There will be a council meeting at 7 p.m., and an ordinary general meeting at 8 p.m., when there will be a further discussion upon "The Self-induction of an Electric Current in Relation to the Nature and Form of its Conductor," by Prof. D. E. Hughes, F.R.S., president.

Edison and the Telephone.—Interviewed about the pending contest, Edison said:—"The principal part of the telephone is mine. The carbon transmitter was invented by me, and is

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in use all over the world. I sold it to the Western Union for $6,000 a year royalty for seventeen years, and the Western Union receives about $300,000 a year for it from the telephone company. That's business, and it's all right. But the Bell monopoly has had a fight for its life in England, France, and Canada, and it is held there by virtue of my carbon transmitter."

ELECTRICAL TRAINING GEAR.—*The Engineer* says :—"The question of training and working heavy guns by means of electrical motors has for some time occupied the attention of the War Office authorities, who have carried out a series of experiments. The system of employing small motors, actuated by a dynamo machine driven by a steam engine placed under cover in a sheltered position, will probably be adopted in preference to the present plan of transmitting the motive power by means of shafting. The guns of the Spithead forts are to be immediately fitted with the new electrical training gear."

TELEGRAPHIC COMMUNICATION AT OXENHOPE.—At a recent meeting of the Oxenhope Local Board with reference to the memorial recently submitted by the Board to the Postmaster-General, asking for the establishment of a telegraph office in the district, the clerk read a communication stating that the application had received careful consideration, but as it was estimated that the revenue from telegraph business would not pay the working expenses an office could not be established except under a guarantee of £38 per annum, under an agreement for seven years. The Board were not in a position to take any steps in the matter.

THE CENTRAL LABORATORY FOR FRANCE.—It will be remembered that some time ago the Société Internationale des Electriciens—which, by the way, is a more energetic body than its English prototype, in that its committees sometimes bring matters to an issue—appointed a committee to report upon the question of the establishment of a central electrical laboratory in France. The report of this committee has been presented by M. E. Sartiaux, and approved by the Council. Whether anything further will come of it remains to be seen. We hear that the motive power provided is ridiculously inadequate for the requirements of an institution of the kind proposed.

POST OFFICE TELEGRAPHS.—A return has been issued, in accordance with an order voted in the House of Commons, showing the gross amount received and the gross amount expended in respect of the telegraph service from the date of the transfer of the telegraphs to the State in 1870 to the 31st day of March, 1885. From this it appears that the total receipts in 1885 amounted to £1,784,414, which sum was less by £36,350 than the expenditure for the same year—£1,820,764. In the year 1884 the expenditure was £1,789,223, and the deficit then was £19,697. These are the only two years since 1870 in which the expenditure has been higher than the receipts.

COMMUNICATIONS WITH TRAINS IN MOTION. — We are informed that Messrs. Edison and Gilliland have concluded a modification of the original idea of Mr. W. Wiley Smith, of communicating with trains in motion by means of static induction between the metal roof of the carriages and a wire running parallel with the line, and are about to make the results public. The apparatus, both on the train and at the station, is said to consist of the ordinary Morse key, a telephone as a receiver, and an induction coil for charging the wire and roofs of the cars respectively. A vibrating reed in the circuit gives a continuous musical note in the telephone, which is broken into dots and dashes by the closing of the Morse key.

THE GROWTH OF THE TELEPHONE.—The growth of the telephone, says the Boston (U.S.) *Transcript*, is one of the most remarkable in the history of inventions. In August, 1877, the number of instruments in use in this country was only 780, while in February, 1880, there were 60,800, 249,700 in 1883, 307,010 in 1884, and in February, 1885, 325,574. There are about 18,000 in Canada, and 13,000 in Great Britain. The number of exchanges has grown from 100 in 1880 to 782 in 1885. In January last there were 137,223 miles of telephone wire in this country. There are 5,186 persons furnished with employment by the exchanges. More different patents have been issued on the telephone than in any other single line of invention in this country. The total number for the ten years is 1,521.

THE INTERNATIONAL EXHIBITION, EDINBURGH. — The machinery department of the International Exhibition will be one of the most important of the kind that has been seen. There will be twelve engines giving power for the electric light and for the machinery in motion, developing in all about 1,400 horse-power. There will be four lines of shafting running through the machinery department, giving power to about 120 exhibitors of looms, spinning machinery, printing, and to paper making, soda water, chocolate, cocoa, and other food manufacturers, as well as about twelve firms of bakers and confectioners. There will also be about 900ft. of steam pipes for conveying steam to prime movers, as well as to the exhibitors requiring steam for their own exhibits. Six boilers are to be provided of 1,200 horse-power.

UNIVERSAL TIME.—At a meeting of the Prime Meridian Metric and Decimal Committee of the Balloon Society, held recently, Mr. Le Fevre, C.E., the president of the society, stated that although the committee had not succeeded to any great extent in the adoption of the 24 o'clock system in this country, it was due to the opposition of the president of the Horological Institute and the "Nautical Almanack." In Australia the telegraphs owned by the Government had carried it out. Spain, Italy, and Germany had partially adopted it. A resolution was moved by Mr. T. H. Hall, C.E., that a deputation should wait upon Lord Wolverton, the Postmaster-General, urging the necessity of transmitting all telegrams from America, the Colonies, and abroad, where the 24 o'clock time is in use, to the postal telegraph offices in the United Kingdom by this new system. The resolution was carried.

THE TELEPHONE IN TORQUAY.—A local contemporary says :—"A petition was on Monday filed against the Torquay Harbour Purchase Bill by the Western Counties and South Wales Telephone Company. There are clauses in the Bill which the companies think will greatly impede if not altogether put an end to their business arrangements, and therefore in self-defence they are obliged to appear in opposition. It seems very undesirable that the Torquay ratepayers should run the risk of having to fight the question of 'overhead' wires, which is really a national one, and ought to be fought out over a special Bill brought in by some responsible authority, such as the Board of Trade, or by some of the wealthier Corporations. It is, perhaps, right that local authorities should have some control over these wires, but the Torquay Local Board ask for very much more—hence the opposition. The Board, it is understood, was offered reasonable terms by the Company, but without result."

ELECTRIC LIGHTING IN HOLLAND.—A contemporary says: —One trifling matter about a little manufacturing town may

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illustrate the difference between the modes of social organisation prevalent in this country and in Holland. There are between two thousand and three thousand residents in the little place, and when the leading inhabitants wished to have it illuminated by the electric light, this is how they set to work. A syndicate was formed, composed of every householder in the town, each one of whom undertook to guarantee a proportion of the nominal capital sum of the combination, assessed to him upon the basis of the ratable value of his dwelling. Thus a small levy all round sufficed to pay for the plant of the concern, and the cost of maintenance and annual working expenses was divided *pro rata*, according to the number of lights used, amongst the householders, no profit of any kind being made by the managers of the works. Under what difficulties, and at what cost, similar little places in England are lighted we all know.

THE ELECTRIC LIGHTING ACT.—Commenting on the desirability of neglecting no means of finding employment for industrious men who have no work to do, the *St. James's Gazette* mentions for one thing that "all attempts to establish a system of electric lighting in the thoroughfares and elsewhere are crushed by the provisions of the Electric Lighting Act of 1882. The restrictions of that Act are so excessive that it is impossible to work under them. To these restrictions Lord Salisbury called attention the other day in connection with the industrial 'depression' which causes so much misery and anxiety just now. The long and the short of it is that nobody dares to venture on electric lighting works on any considerable scale because of Mr. Chamberlain's Act, which virtually extends the Protective system to the gas companies. Reasonable conditions should be imposed on the electric light companies, of course; but they should have a fair chance, and if they had, a great new industry would be developed at once."

THE ALARMIST IN BELGIUM.—After M. Somzee, the gas champion of Brussels and one of the gentlemen who have arrogated to themselves the honour of the invention of the incandescent lamp, had poured four columns of remonstrance against the progress of electric lighting, on the ground of its danger to human life, into the ears of the members of the Chambre des Representants, he was quietly sat upon by the Minister who, while acknowledging the statement of M. Somzee that a number of accidents had in foreign countries resulted upon the use of currents of high tension, remarked that he was not aware that any such accidents had occurred in Belgium. On the other hand, gas was a constant and fruitful source of danger to life, and frequent explosions, which were attended with grave results, had been due to the use of petroleum. He considered it fatal to progress to unduly hamper any industry; but did M. Somzee insist upon it he would be happy to lay his observations before his colleagues, who would, if they thought proper, appoint a commission to inquire into and report upon the best means to be adopted to guard against accidents.

THE NOUVEAU CIRQUE INSTALLATION.—The installation at the Nouveau Cirque at Paris has been formally inaugurated. As now modified, it comprises ten Jablochkoff lamps, eight sun lamps suspended in lustres, and a circle of 400 10 candle-power Edison incandescents. In the boxes and on the corridors and staircases a number of incandescents are variously placed; while five Street and Maquaire lamps light up the entrance. Four sun lamps are always arranged in the *café*. The total number of incandescents in the building is about 1,200. The arc lamps and Jablochkoff candles are supplied in current by two Maquaire alternative current machines, excited by two small Gramme dynamos. The incandescents are supplied by two Edison machines and a battery of 60 Jarriant accumulators. These latter are charged during the day by one of the Edison dynamos. The incandescent lamps are arranged in three circuits, in such a manner as to prevent a complete breakdown. For instance, of each group of five lamps in the boxes two are served by one of the dynamos, two by another, and one by the secondary battery; the circle of 400 lamps is divided into 20 groups, served alternately by each dynamo, and so on. Steam power is employed to drive the dynamos, in the form of a twin-cylinder engine of 120 horse-power, by Lecouteur and Garnier; a spare engine of 25 horse-power has also been provided.

THE ARCHITECTURAL EXHIBITION AT SHEFFIELD.—Among the exhibits at this Exhibition is that of Messrs. Tasker, Sons, and Co., of Sheffield, who make an attractive display under the head of Domestic Electricity. There are electric bells of an improved description for calling the servants; electric bells for attaching to windows and doors which will ring in case either should be left open accidentally at night, or attempted to be opened by burglars; electric bells connected to mercurial thermostats to ring in case of fire, or any undue rise of temperature in the house or greenhouse. Electric telephones are connected to the Central Exchange to accommodate visitors to the Exhibition, and also to demonstrate the convenience of telephone connection in the house; mechanical telephones, which are especially suited for use between house and stable, or house and lodge; electric light machinery for lighting the house by means of incandescent lamps. In wire-sewn leather belting a sample belt is shown measuring 60ft. long by 16in. wide. Here is also a leather belt made for a large firm in the town 80ft. long by 8in. wide, and of three thicknesses. A rubber and cotton driving band, also made for a local firm, is 64ft. long, by 18in. wide, by half an inch thick. Solid woven hair belting has lately come into favour, and the largest belt of this description yet made is shown, being 101ft. long by 21in. wide. A further belt of this class, now being manufactured for local use, is 25in. wide.

WATERMARKING AS A PREVENTION OF FRAUD.—In an article upon this subject in the *Paper Trade Review* Mr. Richard Herring says: Postal orders watermarked for one shilling have been purchased and the watermark altered to ten shillings and twenty shillings. To effect this alteration the paper had been first softened but not resized, and the Post Office consequently suggests that a few light marks should be made with a pen on the back of the watermark, when the ink, we are told, will spread if the paper has been tampered with. Trifles are as expressive as larger things, and if a papermark by machine is to be adopted in imitation and substitution of the original watermark produced naturally on a handmould, there will be no greater difficulty in changing a five pound Bank note into five hundred than has been surmounted in changing a shilling postal note into twenty shillings. However, the substitution of a papermaking *machine* for a paper *mould* will admit of many novel ways of preventing the fraudulent imitation of watermarks so called. The water which dilutes the pulp and the water which dissolves the size are each equally available at different stages of the manufacture to introduce new and separate features and combinations which an electric current will convert into impossible transformation. Indeed, those parts of a money note which have chief importance could be indicated entirely by electricity without printing in the process of making the paper; but why should not the printing with special ink be accomplished before the paper is

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sized and finished, the surfacing metal being ultimately employed to impart a visible and unalterable finish to the notes by electricity ?

ELECTRICAL DEFINITIONS.—On Tuesday last, M. Emile Bède opened a conference on this subject before the Belgian Society of Electricians, Brussels. After premising that the fundamental notion of electrical, like that of physical and mechanical science, is that of work, which is the product of force by length, and the source of which is always energy, either stored up or renewed, the speaker said that in all electrical manifestations the production of mechanical work, whether direct or in the form of heat, could be distinctly traced. Luminous phenomena were often produced at the same time; and, if the unit of light could be defined as exactly as that of heat, it would be easy to establish the mechanical equivalent of light. In electrical, as in other branches of science, great difficulty was experienced in suitably determining the two factors of energy and work called "quantity of electricity," difference of potential," or "electromotive force;" and it might be asked if there would not be an advantage in defining these quantities otherwise than as at present. For instance, if, instead of adopting the units of the C.-G.-S. system, the metre and kilogram were taken as units of length and weight, the product of the quantity by the difference of potential would give the product of the two practical units, viz., the coulomb and the volt; but, for each of the two factors of the product neither the volt nor the coulomb is found. M. Bède also criticised the too great number of terms employed in electrical science, and thought that at any rate electricians might abstain from employing a word to express the flow or delivery of a coulomb per second. Hydraulic engineers had never thought of terming a prony the flow of a cubic metre of water per second, and why should there be a word to express a coulomb contained in a condenser under the tension of a volt ?

SCIENCE FOR THE PEOPLE.—*Apropos* of Prof. Bell's recent suggestion for utilising an overboard telephone wire at sea, the *Daily Telegraph*, a few days ago, edified its readers in the following strain:—"Prof. Bell, who gave us the telephone, promises us an almost greater marvel, as a result of certain experiments which he has been recently making as to the conductivity of water. He has discovered that if a ship trails a long wire behind it in the sea, and that wire is attached to a dynamo on board the vessel, an extraordinary amount of electrical action is at once set up in the waves. Let us suppose this long wire trailing behind an Atlantic liner. The wire may be five miles in length, and it has a dynamo attached to it at its ship end, in full working order. Then the remarkable and unimagined fact which the inventive Professor has revealed to the world is that a powerful electrical current is set up in a circle all round the ship, and that this current is strong enough to influence a telephone which may happen to come within that circle. As the length of the wire is five miles, the diameter of the circle would be ten miles; and thus a ship could surround itself at will with a protective electric circle, which would inform those on board whenever anything approached within five miles. The circular current constantly at work would form a guard to an ironclad far better than any torpedo net ever yet invented; a ship would be able to feel its way in the water by means of the dangling wire just as a cat does in the dark by its whiskers. Now, there is nothing at all new in the fact that water is a good conductor of electricity. This has been known ever since Franklin's experiment with the kite, if not before. Yet it is quite novel and unheard-of that the electricity sent along a wire which is dropped into the waves, instead of passing off uselessly into the sea, should begin to circulate all round the centre at an equal distance, and that the current so established should be powerful enough to set a telephone at work."

THE ELECTRIC LIGHT AND SURGERY.—Mr. Davidson, in the current issue of the *Lancet*, describes an application of the electric light to the opthalmoscope. He says:—The incandescent form of electric light is so convenient in many ways, that it is not surprising to find it has been adapted to sundry medical instruments. To adapt it to the opthalmoscope I finally decided upon the following plan—viz., to fix a small incandescent Swan lamp close to the oblique mirror of an opthalmoscope, arranged in such a way that the light from the lamp should be reflected to a focus in a direct line with the sight hole, so that the brightest illumination should always be exactly in front of the sight hole. As the lamp is fixed to the opthalmoscope and moved with it, it follows that the relation of the illuminated spot and the sight hole never varies. The instrument is intended for the direct method of examination of the eye, and is used precisely in the same way as the ordinary opthalmoscope. The light is pleasant, and quite as well borne as the usual gas or lamp light used in opthalmoscopic examinations. By this arrangement it is easy for an inexperienced person to see the fundus oculi, and especially so if the pupil be dilated. The light is on the spot he looks at, and always follows the movements of the instrument. The light is never lost. On this account it may prove a useful demonstrating opthalmoscope. The colour of the parts is nearer that seen by daylight than can be got by the ordinary artificial light. The lamp can be detached in a second, and used independently for oblique illumination in examining the cornea or lens. I have used this lamp in needling operations. The opthalmoscope can be used in the ordinary way, since the oblique mirror can be removed, the additions in no way interfering with it. As to the source of the current, I have used lately four cells modified Leclanché battery. This gives a moderate light for about eight minutes, and then requires 20 minutes' rest. The bichromate battery, as employed at Moorfields Eye Hospital, is probably the best form of stationary battery. Two small Grove cells will give a good light with this lamp for three or four hours or more. Pocket accumulators have hitherto disappointed me. Mr. Joseph Swan has recently made a reliable accumulator, which is quite portable, and, fixed with a specially constructed Swan lamp, gives a good light for 12 hours. It can then be recharged.

THE ELECTRIC LIGHT IN CHICAGO.—Among the large installations which have recently been completed in Chicago may be mentioned those at the City Hall, the Washington-street tunnel, and the Lasalle-street tunnel. The plant at the City Hall, as furnished by the Edison Company, cost something over $40,000, the engines being built expressly for this purpose. The engines are odd in size, the cylinder of the larger measuring 21 by 15in.; that of the smaller 18½ by 15in., and when running at full speed they each make 240 revolutions per minute. When running at this high rate of speed the four dynamos will generate electricity for 1,600 incandescent lights of 16 candle power. The limit number of lamps that will be required at any one time is 1,400. Three hundred of these have been reserved for the tunnels, connections being made with the City Hall wires by means of cables laid in pipes, as furnished by the Underground Conduit Company. In the Lasalle-street tunnel 134 lamps will be kept constantly burning, with 26 extra lamps for night use only. The Washington-street tunnel will have the same number of night lamps and 100 for constant use. It has

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required the laying of 12,800ft. of cable to transmit the current for the tunnels, and in this connection may be mentioned the fact that this is the only plant in use in this city where two sets of lights with distance intervening are kept burning at the same time, the candle-power being equal in both, and that regardless of the number of lamps burning in each set. Another very important feature is that the plant is so constructed that the two distinct sets of lamps (the City Hall and the tunnels) can be operated upon a common circuit by one or any number of machines, or the two sets can be operated upon totally distinct circuits and by separate machinery, so that the shifting from one method of operation to another can be made with perfect ease, and without affecting the candle-power of the lamps a particle. The Washington-street tunnel is about 1,280ft. in length, and the distance of the dynamo from the centre is 1,950ft. There are in this tunnel 128 16 candle-power incandescent lamps. The length of the Lasalle-street tunnel is 1,800ft., the distance of the dynamo from the centre 1,450ft, and the number of 16 candle-power lamps is 166. For this service feeders are laid underground in a special Dorsett conduit. At the City Hall the electrical and mechanical plant is located in the basement. There are two Armington and Sims engines, two No. 12 Edison dynamos, and a No. 16 dynamo of the same type.

Aluminum.—In a recent paper to the Franklin Institute, given in full in the *Journal* of the Institute, Mr. Cowles describes the method of obtaining aluminum and its alloys by the use of his electric furnace. After describing his furnace (*vide The Electrician*, Vol. XV. p. 411), he goes on to say, "All is now ready for the charge, which is prepared. Should it be desired to produce aluminum bronze, we mix sixteen or eighteen pounds of granulated copper, twelve to fourteen pounds of aluminum oxide in the form of broken corundum, and several pounds of coarsely broken charcoal together, burying the electrodes with the same, and thus filling the space inside the walls of the sheet-iron gauge. The gauge is then lifted from the furnace, additional coarse charcoal is spread over the entire mass, the iron top of box is put in place, the seams luted with fire clay, the current from the dynamo switched on, and the furnace is in operation in but little more time than it has taken to give these apparently trifling but very important details. We will now proceed to make a little study of the philosophy of the process, after first watching a successful 'run' or 'heat' from the beginning to the close of the operation. Of course, the furnace and its contents, when the current of electricity was turned on, were entirely cold and the resistance presented to the flow of the current consequently is higher than it would be at any time during the 'heat,' unless some unforeseen accident, such as a slight explosion of gas, takes place. But notwithstanding that the furnace is cold, a complete metallic circuit, with carbon tips dangerously near together, is ready to convey a one hundred horse-power flash of lightning into the furnace, should a short circuit occur. There are likewise many pounds of pure copper in between and about these carbon tips that may be melted and run together and thus produce a short circuit. With these conditions an electrician would insist that the man in charge of the furnace should look pretty sharply lest the four-thousand dollar dynamo at the other end of the wire be burned out, or somebody be injured by a heavy flash. The man in charge, however, has anticipated such a contingency by having thrown in several coils of the resistance box, so that under no condition, even if the great carbons in the furnace were pressed tight together, would the dynamo be able to produce a current of more than 1,600 amperes, the maximum load. Upon watching the amperemeter, however, it is seen that this precaution was not necessary, for only about 200 amperes are indicated as flowing; the artificial resistance is, therefore, slightly diminished; the needle of the ammeter moves up rapidly to 600 or 800 amperes. Suddenly it gives a jump up to 1,200, then back to 200, then with a bang the armature of the ammeter is brought against the magnet, and it registers 1,600 amperes of current flowing and then instantly drops back to almost zero. As every jump of that needle means wear and tear on the commutator and brushes of the dynamo, care is now taken to keep more control of the current, and a little more artificial resistance is thrown into the circuit. The needle now moves more slowly around the dial, gradually making fewer and fewer jumps, and at the end of eight or ten minutes, it has worked up to the 1,000 ampere mark, and becomes quite steady. Suddenly there is a hiss and a sharp report, a tongue of greenish yellow copper flame darts upwards from the hole in the furnace top and then disappears, to be followed after a minute or so by a slight vapour. This was caused by the monoxide of carbon combining with the atmosphere in the furnace to produce an explosive compound. To prevent this gas from accumulating to an extent to raise the furnace top and loosen the luting, the attendant holds a lighted stick over the vent and a series of slight explosions follow. Soon a characteristic yellow-white flame appears above the hole, the needle registers about 1,200 amperes of current flowing, all of the artificial resistance is withdrawn, and the process of reducing aluminum and alloying it directly with copper is completely under way. Soon the needle gradually creeps around the dial to the 1,400 or 1,500 ampere mark. This is regarded as being a little too hot work for the dynamo and at the same time the plume of flame above the furnace indicates a little less rapid reduction. There are, therefore, two things now necessary. The first is to put more resistance into the circuit, and the second is to put more ore into the zone of reduction. These are both done by withdrawing one of the electrodes and the ammeter needle drops back to 1,200, and the flame above the furnace soon gives evidence of doing more work, by reason of more copious white fumes being given off. This pulling out of the electrodes is repeated over and over again until both are out to their full length. At the end of an hour the 'heat' is completed. The current is then switched to another furnace, but one furnace being used at a heat. The artificial resistance is again resorted to, enough being thrown into the circuit gradually, thus slowly choking off the current, permitting the proper regulation of the brushes on the dynamo, and also giving time for the engine to govern itself. Finally, at the end of several minutes, the switch is thrown open and the furnace is entirely out of the circuit. Furnace No. 2 is now operated in precisely the same manner as the furnace No. 1, which is allowed to cool off. At the end of two hours furnace No. 2 is thrown out of the circuit and work begun on furnace No. 3. By this time No. 1 is ready to be discharged. The lid is removed and water is used with a sprinkling pot to quench the fire still remaining. At the bottom of the furnace, on the floor of fine charcoal, is found an oblong metallic and crystalline mass of white metal. It is the copper charged with from 15 to 35 per cent. of aluminum and a small quantity of silicon. It frequently averages 20 per cent. to 22 per cent. of aluminum and silicon. Covering this mass is also found a considerable quantity of fused carbide of aluminum. Analysis of this product has shown 30 to 60 per cent. of metallic aluminum present. On cooling, it forms very large and distinct crystals."

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TELPHERAGE.*

BY PROFESSOR JOHN PERRY, F.R.S.

In my preliminary lecture last week I tried to show you

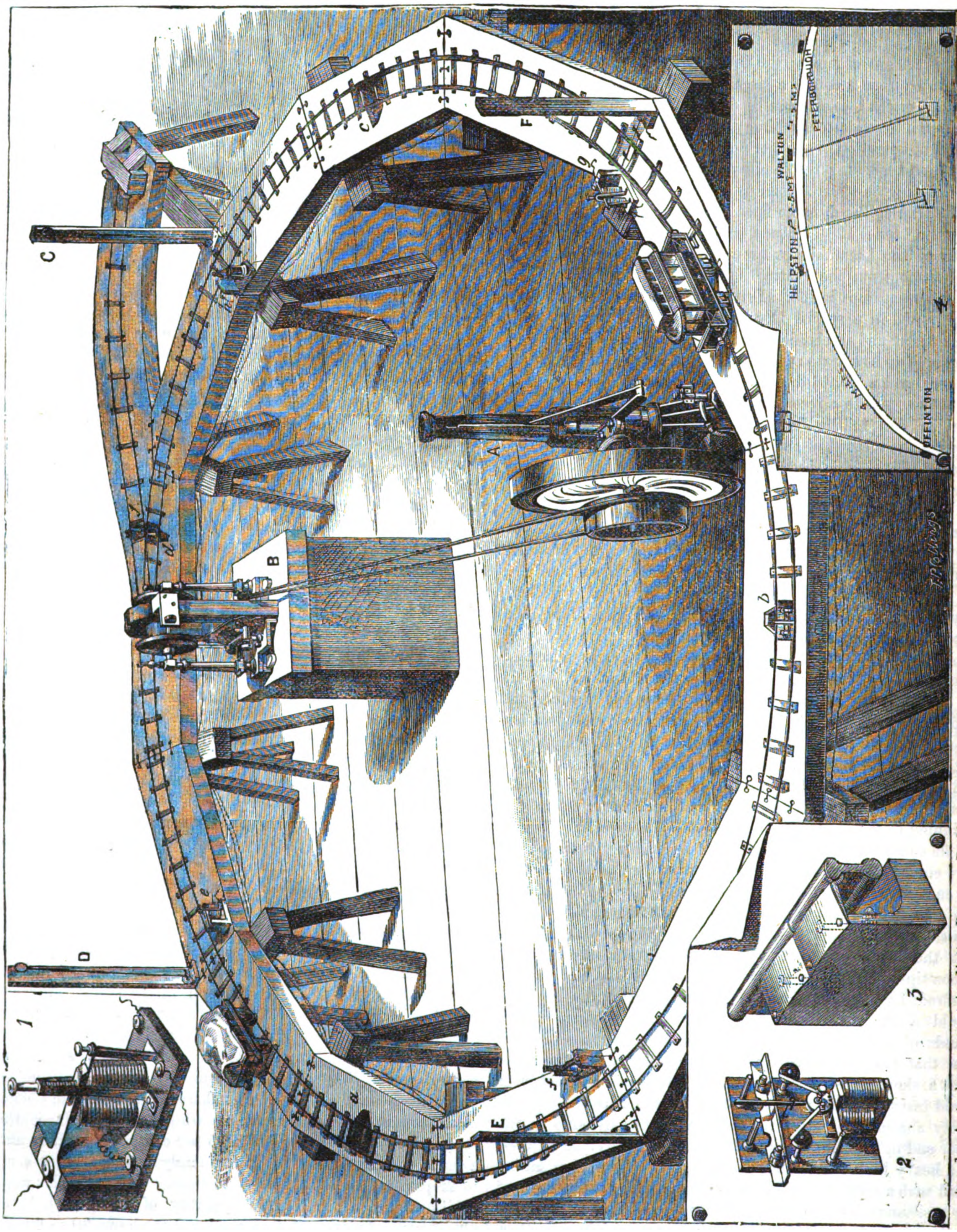

Fig. 1.—A. An Engine supplying Motive Power. B. Magneto-Electric Machine. C, D, E, F. Electric Current Indicators. *a, b, c, d.* Contact Makers at the ends of each section. *e, f, g, h.* Blocking Electro-Magnets attached to each section. 1. Blocking Electro-Magnet (enlarged). 2. Contact Maker as in the Model. 3. Contact Maker required for actual use. 4. Map Indicator for automatically showing the position of the Trains on the Line.

why it was that we spoke of a *current* of something flowing in a circuit from one of our generators, and also our reason for calling it a current of *electricity*. I proved to you that our method for measuring the loss of electrical energy in any portion of the circuit was a correct one, and I showed you what were the difficulties in transmitting electric power to great distances, due to the heating of the conductors. As the power which must be received at a distant place depends upon the available

* Lecture delivered at the London Institution on "Telpherage," 28th January.

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potential there, and as the available potential there is less as the distance is greater and as the current is greater, and as the current itself must be greater for a certain amount of power the less the available potential, the lessening of this available potential is more rapid than the increase of distance. In describing the wonderful results obtained by M. Marcel Deprez at Creil, I pointed out how different our problem is in England, where on such telpher lines as that at Glynde we are limited to an electric potential or pressure of 200 volts instead of the 6,000 volts employed by M. Deprez. I further showed you how the potential falls off along such a line when carrying 84,000 tons per annum, and that we might have such lines working very economically ten miles long, even with the restrictions imposed upon us by the Board of Trade.

The energy employed in the driving of carriages must either travel with the carriage in a stored condition, as it is stored in a horse or in the coals of a railway locomotive, or in the compressed air of some forms of tramway locomotive, or in the electrical accumulators which Prof. Ayrton and I have carried on our electrical tricycle and in tramcars ; or the energy may be conveyed to the carriage from a distance, as in wire rope tramways and other cases of haulage, and in the pneumatic tube system.

Electrical power seems to be the only kind of power, with the exception of that which is used in haulage, which can readily be transmitted to a rapidly moving carriage, and its applicability in this case seems to have struck inventors very early in the history of the applications of electricity, so that models of electric railways, worked from voltaic cells, have been used for a considerable length of time. As soon as the discovery of the Dynamo Machine gave us the means of producing electrical power readily in large quantities, the Siemens railways in Berlin and at the Paris Exhibition were constructed, and not long afterwards the electric tramway at Portrush, which is six miles long, was made, as well as a very much shorter one on the beach at Brighton, both being now in daily use. In electrical railways it is of the greatest importance that one of the conductors should be well insulated from the other; that is, as I explained in my last lecture, that it should not be possible for leakage to take place from one to the other. In the Siemens' tramway along the Champs Elysées leakage was prevented by carrying both the conductors or insulators above the level of the tramcar on wooden structures, a plan to which there are many serious objections when proposed for a general system of electric railways. On Brighton beach the line is so short and the shingle on which the sleepers of the tramway rest is so well drained that sufficient leakage does not occur to materially affect the working, although the rails themselves are the two conductors. In this case, therefore, where the motor on the tramcar receives a current through metallic contacts with the two rails, it is driven wherever it may be on the line. On the Portrush tramway, however, which, as already mentioned, is six miles long, this method was found to produce too much leakage for practical working, and one of the conductors had to be raised about two feet above the ground. This conductor is a stiff T iron, which is supported on many wooden posts, and is insulated from the posts. Long before either of these two railways was projected, my colleague and I saw that the plan used at Lichterfelde, near Berlin, and now employed at Brighton, was the only one which promised success in a general system of electrical locomotion; but to avoid the excessive leakage that would occur on long railways, it would be necessary to divide the railway up into sections, and arrange matters so that the rail to be rubbed should be automatically connected with a buried well insulated conductor just when a train was in the neighbourhood. By this device leakage would only occur on a short length of the railway at any instant, so that the leakage on a long electrical railway would be actually less than on a very short railway made in the older way. We further saw that this division into sections enabled us to provide an automatic block of a far more perfect kind than any known in ordinary locomotion. It was analogous to the instantaneous removal of all steam, and coal, and heat from an ordinary locomotive when it was approaching dangerously near another train in front of it, and all this would be effected automatically without the agency of a driver, guard, or signalman. Our plans were all simple, and some of them would have enabled us to obtain good insulation of the line even if the rails had been covered to the depth of a foot with water. I will now throw on the screen the slide (Fig. 1) taken from the large wood cut published in the *Graphic* newspaper, showing the model which illustrated our system in a lecture delivered by Prof. Ayrton in 1882, before the Royal Institution.

[Prof. Ayrton had provided two trains, one moving slowly, which represented a goods train, and the other moving much more rapidly, representing an express train, following it. It was interesting to see the attempts made by the express train to catch up and run into the goods train, and the way in which it was constantly being stopped by its supply of electric power being cut off whenever it came within a certain distance of the goods train in front of it.]

By this time it had become evident that the success of our insulation method, important as it was, was of less moment than the automatic block, which enabled carriages to be run without any attention from drivers, and after Prof. Ayrton's lecture we received many suggestions of possible applications of the principle of the automatic transmission of carriages by electricity.

We had already made sketches of two forms of overhead single rails, with wheels running on them from which hung the loads to be carried.

Among the suggestions we received regarding possible uses of our "Absolute Block" was a very valuable one sent us by Prof. Fleeming Jenkin from Edinburgh, describing an overhead railway, which should consist of a single wire rope, which was itself the carrier of weights, and also of electricity. As he himself said in his introductory address to his students at the University of Edinburgh, he had long had the idea that there must be some method of propelling electrically a continuous stream of light trains along an elevated single rail or rope, but that he did not see his way to carry this idea into practice until he read an account of Prof. Ayrton's lecture at the Royal Institution, when it was plain that the plan of sub-dividing the rail electrically into sections and of providing an automatic block would enable him to have a great number of trains following each other without drivers, and without there being any danger of collision. The position held by Prof. Jenkin in the engineering and scientific world was such that we shall always consider it a great honour to have been asked by him to become his partners in any scheme of this kind, and we gladly accepted his offer to co-operate with him in developing a system of automatic electric transport, to which he gave the name of "*Telpherage.*"

The first model of a Telpher Line was designed under our supervision and that of Prof. Jenkin (whenever his duties in Edinburgh allowed him to come to London), in our own drawing office, by Mr. Archibald Elliott, an old pupil of Prof. Jenkin. It was erected in a studio in Fitzroy-street, and being seen there working by certain people interested in practical science, led to the formation of the Telpherage Company, whose function was to experiment on the plans of automatic electric transport suggested by Prof. Jenkin, Prof. Ayrton, and myself.

In that model Prof. Jenkin's first idea was employed of using what is called a "*Series System.*" This system is not the one which we are practically employing, but it will probably be immensely developed in the future. In Fig. 2 you will see

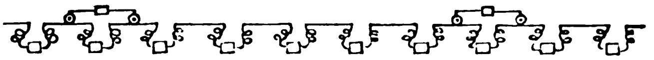

Fig. 2.

the principle of working. Figs. 3 shows a view of the locomotive, and Figs. 4 and 5 show an elevation and plan of the locomotive, train, and telpher line. In Fig. 3, A is the wire rope, gripped by the two wheels O and O, which are driven by the two little motors J and J. The two wheels, O and O, are pressed together by means of the levers L, L, and the springs shown in Fig. 5. There are grooved supporting wheels for the locomotive and the carriages, each carriage being like a pair of panniers, one hanging down

on each side of the rope. The rope is in sections of equal length, like A, B, C, D, &c., of Fig. 2. When there is no train on the line, all the sections are connected metallically together,

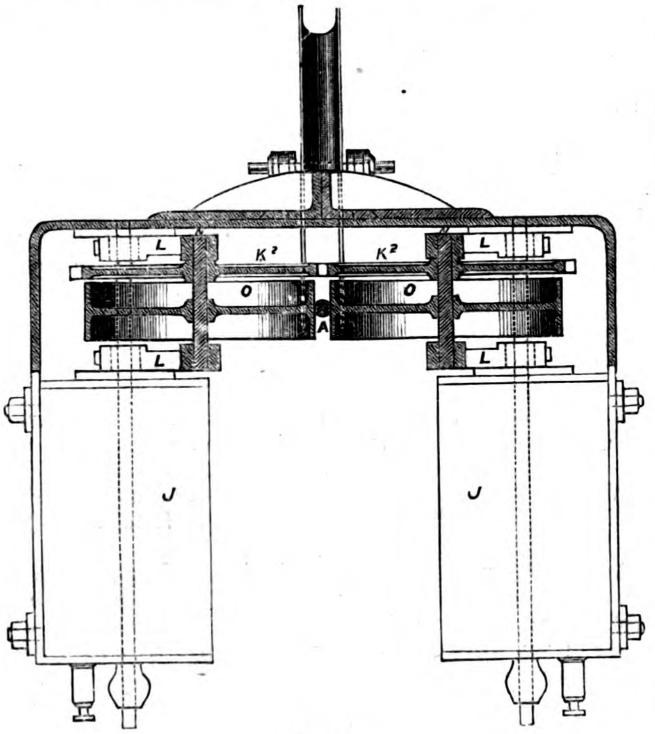

FIG. 3.

and form part of the circuit of a dynamo machine which is completed by the ground. But when the front of a train comes to the end of section A it touches a lever, which breaks the metallic connection between A and B. When the metallic

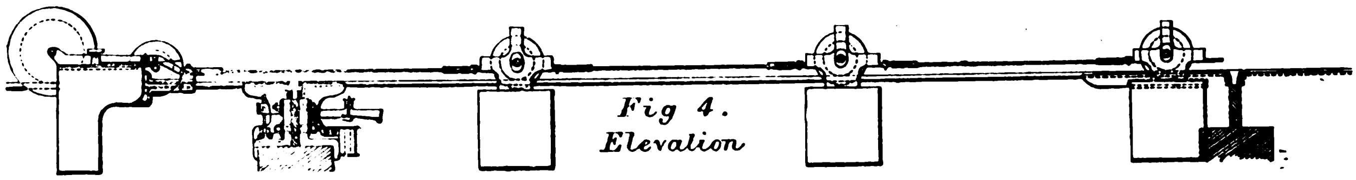

Fig 4.
Elevation

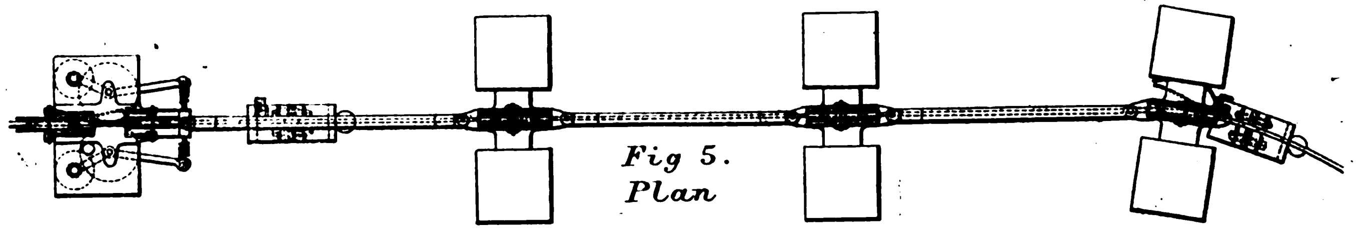

Fig 5.
Plan

connection is broken the current from the dynamo would cease to flow, but that a wheel on the front of the train touches B, and another behind touches A, and as these wheels are connected by means of two wires to the terminals of an electromotor, M, the circuit is completed through the train. And as a train is always bridging a gap, it continuously receives electric energy, and is propelled forward. The fore part of the train opens gaps, and the hind part closes them.

I am afraid that it would be impossible in one hour to give you, as I wish to do, a general idea of telpherage, if I now waited to describe in detail the block systems in use by us; but if you examine this model after the lecture you will readily understand, at any rate, one of the simplest of the dozen or more methods, differing in principle from one another, which we have described in our patents.

Until the formation of the company the great difference between the electrical methods of working of Prof. Jenkin and ourselves was in that he worked on a *series* principle, and we work on what is called the *parallel arc* principle—that is, the motors of his trains were all in one circuit, and the same current passed through them all; whereas we let each motor take its separate portion of the whole current, as incandescent lamps usually do in electric lighting. The diagram will explain the distinction. Fig. 6 shows the series system, and Fig. 7 shows the parallel system, A, B, C, &c., representing the motors, and X the dynamo. The series system can be

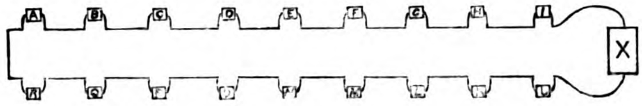

FIG. 6.

shown to be much more economical, and to be much simpler in the arrangements necessary for maintaining a constant speed; but it requires the use of motors which will take large currents, or else the use of dangerously high potentials in the conductors.

From the time of the formation of the company, we are sorry to say that, although the three inventors were to share

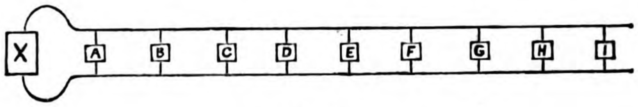

FIG. 7.

equally in any profits which might arise, they ceased to have equal shares in the credit of developing the system. It would be difficult to convey to a person who was not acquainted with Prof. Jenkin how hopeless it was to compete with him in the practical working out of an idea; and although, of course, much credit in working out the idea must be given to Mr. Jameson and the draughtsmen and other members of the Telpherage Company's staff, and to the directors of the company, and very greatly to the chairman of the company, on whose estate at Weston experiments on a working scale were entered upon immediately after the formation of the company, yet Prof. Jenkin was felt by every one to be the soul of the enterprise. Soon after those experiments commenced, he conceived a most marvellously simple method of working trains on a single line, which had not the disadvantage of the series system in requiring the train to strike an electric key, thus breaking the circuit at the head of every post. The practical objection to this striking of a key by the train had been so strongly felt by us, that my colleague and I had not only patented a great number of methods of contact making and blocking on our parallel system, but also on the Jenkin or series system. However useful these methods may turn out to be at a future time, their immediate necessity was completely done away with when the discovery was made by Prof. Jenkin of this "Cross-Over System," in which the trains are worked in parallel arc. The line is, as before, divided into sections, and sections A_1, A_3, A_5, A_7, &c., Fig. 8, are metallically connected together, and to one pole of the generator of electricity. Sections A_2, A_4, A_6, A_8, &c., are metallically connected together, and to the other pole of the generator. One of the

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sets is of course well insulated from the other. Now the train is long, and there are two wheels on the train which are employed for making contact, and you will see that when wheel L (the leading wheel) is on what may be called the negative section A_2, wheel T (the trailing wheel) is on a positive section A_1, or when wheel L is on any positive section, wheel T must be on a negative section. The result is, then, that as the wheels L and T are electrically connected through a motor on the locomotive of a train, by means of a copper wire, which is insulated from all the other wheels of the train, the motor receives a supply of electric energy. Now, we saw last week that a motor runs always in the same direction whether or not the current that is made to pass through it may be reversed; it is only by altering the connections on the motor itself that we can cause it to run backwards; consequently whether wheel L be on a positive section and T on a negative, or T on a positive and L on a negative section, the train will be propelled forwards. You will see, too, that when an up line and a down line are required, the cost of metal in making the connections is very much lessened; for if the section A_1 is a positive section on the up line, the section B_2

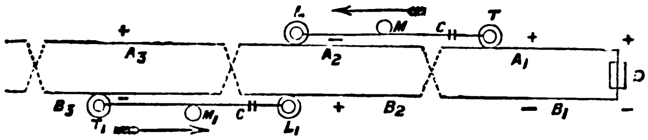

FIG. 8.

may be made a positive section on the down line, and the connecting wires are only 8ft. long, although the sections themselves may be 60 or 70ft. long.

This model shows the working of the cross over parallel system with an up and down line. [Model here shown.]

It is true that just as in Prof. Jenkin's first system, so in his new system, the sections into which his line is divided must be equal to one another, and this is sometimes inconvenient, as when broad gorges have to be crossed, and at curved parts of his line. But this difficulty can to some extent be overcome by employing what we call a *gravitation section* longer than the distance between the contact wheels of the train. This section is constructed with a downward slope, so that the weight of the train will propel it over the part in which it receives no electric energy. There is a defect in the cross over parallel telpher line which did not exist in the series system, viz., that at the end of every section the current passing through the motor is stopped and reversed.

The cross over parallel system is now at work at Glynde, in Sussex, and, as far as we know, our anticipations of success have been completely verified. Experience in the daily working of the line at Glynde has shown the necessity for the conductors of the motor having a higher insulation than usual, on account of the reversals of current, and this may cause us to introduce improvements which may to some extent diminish the simplicity of the system, which is at present very great. To give you an idea of how excessively simple it is, I will now show you a working model of a telpher line constructed in accordance with the first Ayrton and Perry patent. The plan consists in placing at intervals along the line, but not necessarily equal intervals, stationary brushes, or forks, or pulleys, all connected with the insulated terminal of the dynamo machine, and carrying a conductor on the train, which is always in contact with one or more of these brushes, or forks, or pulleys. Of course, the wire rope or steel rod which carries the train need not be insulated, and is the return conductor in connection with the other terminal of the dynamo. In this model you see that a copper wire hangs from the two ends of the train, and that no swinging can prevent the wire from falling into the forks, so that wherever the train may be on the line it will receive a supply of electric energy. This model before you shows how readily on this system a gorge may be crossed which is a great many times the length of the train, as the contact forks can readily be carried by the suspended rod. [The train was here run backwards and forwards along a span supported by two posts at a distance apart equal to ten times the length of the train.]

(To be continued.)

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The discussion upon Prof. Hughes's paper on "The Self-Induction in Electric Conductors" took place on Thursday evening, 11th inst., at Great George-street, Westminster. Sir CHARLES BRIGHT took the chair, the president, Prof. HUGHES, yielding that position during the discussion of his paper. Prof. HUGHES then offered a word or two of explanation in regard to Diagram 2 of his paper. The results shown were all for wires of 30 cm. length, which gave relatively the same E.M.F. for all currents.—Lord RAYLEIGH, in opening the discussion, expressed some doubt whether the definitions employed in the paper did not differ from those of Clerk Maxwell, a circumstance which threw some uncertainty in the way of discussing the facts scientifically. Also, as regards the ratio of the self-induction to the resistance, he questioned whether the difference in resistance of the various materials examined had been sufficiently taken into account. But there was no doubt that in several particulars Maxwell's theoretical expositions had now been confirmed by Hughes experimentally. Examining diagrammatically the method employed by Hughes, he, however, apprehended that there might be some danger of confusing the effects of induction with what were perhaps really due to resistance. These differing effects he thought were not certainly indicated by the Hughes instrument. Especially he could hardly conceive the self-induction of a stranded being less than a solid copper wire. If this were so, some of Clerk Maxwell's expositions would have to be reconsidered. Prof. Hughes's statements with regard to carbon were also novel, and would need further explanation. As a contribution to the subject in hand, Lord Rayleigh described some experiments of his own to determine the behaviour of iron and steel under very small magnetic forces. They were important as affording an explanation of the action of a telephone. He had found that its soft iron core in juxtaposition with a permanent magnet was precisely that condition most favourable to its sensibility to any disturbing effects; that is to say, its magnetic condition was considerably above that of the earth's magnetic force, but much below that of saturation.

Mr. FRANK POPE, editor of the New York *Electrician*, pointed out how the result of these investigations had satisfactorily explained several electrical phenomena which had long been a puzzle to practical telegraph-engineers in America. Notably the reason now given for the otherwise unintelligible fact that a lighting current would fuse a fine iron wire rather than take the course of a thick wire to earth. Secondly, it had long ago been observed, but nobody could give a reason for it, that working fast-speed instruments between New York and Philadelphia the speed obtained on a stranded wire was far in excess of that attainable on any other class of wire. A similar superiority had been noticed in the case of an iron wire which had a coating of copper. Prof. Hughes's experiments went to explain these peculiarities.

Prof. FORBES spoke in high terms of the paper, and confessed the great interest he had taken in the progress of these experiments. He then proceeded to indicate three important applications of the work of Prof. Hughes. The first point was the superiority of stranded wire to solid iron wire. The second point was in relation to lightning conductors, where Prof. Hughes has shown that the self-induction of a thick copper rod was so great as to cause the lightning preferably to come through the thin wire. This example of electro-magnetic momentum, he said, was analogous to the case of momentum in mechanics illustrated by the bursting of a gun whose muzzle is plugged with loose earth. The third point was in connection with submarine cables. For some years he had insisted upon the serious retardation produced by iron sheathing of cables, and he felt sure that Prof. Hughes's experiment would lead to the eventual abolition of this cause of retardation. Speaking of the theory relating to Prof. Hughes's experiment, he agreed with Lord Rayleigh in having some difficulty in understanding Prof. Hughes's terms. Lord Rayleigh had explained the application of the theory developed by Maxwell, but he (Prof. Forbes) thought there was something more. He showed that the E.M.F. of induction must be greater in the centres than in the outside of a wire, and consequently there may be sometimes a current in the centre of the wire contrary in direction to the main current, the outer part of the wire forming a short circuit to this induced current. The energy consumed by such an eddy current, or by the main current being confined to the outer parts of the wire, is in the nature of a resistance, and does not change sign with an increase or decrease of the current, as self-induction is generally supposed to do. This explains how Prof. Hughes obtained a different value for the resistance of a wire in the variable state, and in the stable state. He had applied this theory combined with the views put forward by Lord Rayleigh to all the experiments contained in Prof. Hughes's paper, and found that in every case the experiment was in accord with theory.

After a few remarks from Dr. HOPKINSON the discussion was again adjourned.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 *p.m.*

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SCIENCE AND DEMOCRACY.

In the discussion which has followed the republication of Sir HENRY MAYNE'S remarkable essays on "Popular Government," our cousins on the other side of the Atlantic have taken a lively, if not very profound, interest; and one of them, Mr. E. L. GODKIN, of New York, has favoured us with the American view of the question in the current number of the *Nineteenth Century.* Mr. GODKIN'S case is argued with characteristic acuteness, and is so admirably written that whatever else may be charged to American Democracy it has plainly not altogether destroyed those qualities which favour the growth of first rate literary workmanship. Whether America is the "awful example" in some other directions which Sir HENRY MAYNE asserts it to be is quite another question, and one which we may safely leave him to fight out with his critics here and abroad. But on the point which particularly interests us, namely, whether the democracy is favourable to Science, as Mr. GODKIN contends it is, or hostile, as Sir HENRY MAYNE pronounces it, we think the American will get the worst of it. Not that his argument is any less incisive on this topic than on the rest; but his material falls far short of his needs. In fact, we suspect from the language he employs that he scarcely appreciates the real point at issue, simply through misunderstanding what Science really means. If we are right in this conjecture Mr. GODKIN is an instance of what he calls "passion for equality" having dulled the intellect against the apprehension of scientific truth. At all events, he makes it plain to us that a good deal of what passes for Science in the United States is what in England would be called charlatanism and the explanation he gives, so far from mending matters, only makes them worse; for it is a virtual confession that the People prefer what is at their own level, and are rather angry with Science for not coming down to it, which is pretty much what the English political essayist says about them. He could hardly say anything worse.

Recalling the Presidential Address at the last meeting of the British Association and the criticism it provoked, the warnings of Sir HENRY MAYNE and the admissions of his Democratic opponent are of interest to us just now. The recent appeal of the Royal Society to its members for additional funds to further the cause of independent research may be said to be on the old and safe lines of constitutional usage. One, though not perhaps the chief, aim of this Society is to benefit the people, whom, however, it neither consults nor invites to co-operation. But the endowment of Science for and by the people is a proposition obviously of quite another kind, more in accord with American notions than with those which have hitherto prevailed in the mother country. The idea is not, however, objectionable solely on that account. We have criticised it on its merits already. But in the light of Mr. GODKIN'S article some other grounds of objection and cause for misgivings are laid bare which are well worth considering. Sir HENRY MAYNE had pointed out as one of the evils of Democracy—meaning by that term a form of Government in which the popular element of numbers is predominent—that there always exists a "marked antagonism between democratic opinion and scientific truth," an antagonism which tends to develop into "the worst form of conservatism"—that is to say, the conservatism which rejects new revelations of science, whether in the sphere of philospby, politics, or religion, if they come in conflict with popular habits, prejudices, or beliefs.

Now, as regards this proposition, we suspect there are but few people in these islands who would take the trouble to gainsay it; most of us would, we imagine, accept the facts; and, if friendly to Democracy, might contend that they were not of sufficient gravity to affect the main question. We have seen enough of such popular hostility even here within the past half-century; nay, we are witnesses to a vehement outburst of it at this moment; and the only matter still in doubt is whether the people will enforce that "form of conservatism" if they have the power. But this is a question for English politicians. From America the answer is not encouraging, though Mr. GODKIN does his best to make it so. He begins by an admission which at once fills us with consternation. "No one can deny," says he, "that in regard to matters which can become the subject of legislation the American voter listens with extreme impatience to anything which has the air of instruction. . . . The passion for equality is one of the very strongest influences in American politics. . . . The orator [who addresses the Democracy on public questions] has to keep carefully, in outward seeming at least, on the same intellectual level as those whom he is addressing." And further on we gather that any political speaker who presumes to instruct his audience as to what opinions they should hold is contemptuously dismissed as an impertinent fraud. It would therefore seem that what Prof. HUXLEY in the same magazine ironically calls "the modern ideal of a leader of men," which is to stoop to be "a representative of *average opinion*," has been already fully realised in the American Democracy, and with results for Science which are rather depressing. Science, it is true, is listened to with more respectful attention than Politics can command; but when Science becomes the "subject of legislation," as, of course, it often ought to be, the American people look to their votes for inspiration and reject all external influence. The

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doctrine that the bestowal of a vote confers all wisdom of the political sort is not new to us. We have now to learn, it appears, that it is equally efficacious in the domain of Science.

Mr. GODKIN gives a curious illustration of popular departure from orthodox Science in the fact that quacks and quack nostrums are popular in America to an extent, "the like of which can be seen nowhere else." His explanation is even more remarkable than the fact. It is due, he says, to popular "impatience with the caution and want of enterprise of the regular practitioners"; and the context shows that he thinks this a satisfactory account of the matter. Science is "cautious," and is therefore deserted for quackery; it lacks the characteristic "enterprise" of imposture, and has therefore only itself to blame. To be a leader of men in scientific as in political affairs the one thing needed is to represent "average opinion;" anything above the "intellectual level" of the multitude is an affront to their "passion for equality," and is therefore precluded in a general way from designing beneficial "subjects of legislation." The case of Mr. EDISON, who is cited as an example to the contrary, is, we fear, not altogether reassuring. After he had made some improvements in electric lighting and invented the phonograph he was "hailed as a man to whom any problem in physics—or physic? —would be simple. In fact, for a year or two he held the position of a 'medicine man,' to whom any mystery was easy." This is adduced as a "very good illustration of the respect of American people for the novel and the marvellous;" and nobody can doubt it. But it is no proof of their respect for Science. The Democracy, in short, although evidently a capital field for "medicine men," is not a very promising region for genuine scientists. We may hope the latter will not be discouraged in their pursuits; but we dare not predict that their discoveries will long be welcomed as "subjects of legislation" in the democratic era upon which we are now said to be entering.

ATLANTIC CABLES.

Two notes in our last issue require some explanation, inasmuch as they convey an impression which is altogether erroneous. The authority for the information given was from circulars issued by the Mackay-Bennett Cable Company, which appeared also in the *New York Herald*. As a matter of fact, the Atlantic cables of the Anglo-American, the Direct United States, the French, and the Western Union Companies were all efficient, and in as good working order at the time indicated as were the Mackay-Bennett cables. The land lines, however, of America had suffered from the stormy weather, and some of them were broken down. Still, there was no material interruption of traffic sent over the English cables. The statement that the communication between Europe and America "might have been entirely interrupted for many hours on the 29th ult. had it not been for the Mackay-Bennett Cable," was utterly at variance with the facts. With regard to the quick work, the time specified is so common and has been so frequently beaten that the other Atlantic Companies never thought of putting such a feat on "record." Hence, while the fact may be true as regards "the record," no special credit can be attached to the performance. With these arbitrage messages, it is almost a daily—we had nearly said hourly—experience to send a message from this side, or from the other, and receive the answer not only within six minutes, but often in less time. Our cousins are adepts in *double entendre*; they say one thing, leaving the hearer or reader to accept another meaning. The cables of the Mackay-Bennett Company are subject to the same laws and risks as other cables, and are not specially insured to remain intact while other cables fail. It may be taken as probable that the chances are somewhere about 45 to 1 that both the Mackay-Bennett cables are themselves broken rather than there should be a complete breakdown of the cables of the other companies.

CORRESPONDENCE.

RESISTANCE AS VELOCITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As the subject of nomenclature is under discussion, may I take the opportunity of protesting against the loose mathematical diction often used, especially in connection with resistance? Because the change ratio of the electro-magnetic unit of resistance is $\left[\frac{L}{T}\right]$, people talk of a resistance of so many metres per second, which is an insult to common sense. It seems as if no one likes to protest against this loose mode of speaking, because it is sanctioned by so many eminent authorities. Sometimes we read that resistance is velocity; sometimes that it is homogeneous with velocity, or of the same order of nature as velocity; which appears to be a more verbose way of saying the same thing. Sometimes we read that resistance is *a* velocity, as if there were different kinds of velocity, resistance being, perhaps pink, "rotten-orange," or piebald velocity. It is odd that the use of "mixed" mathematics is not extended. We do not yet hear of this or that substance having a specific resistance of a quarter of an hour, or of a coil with a co-efficient of self-induction of a parasang.—Yours, &c., JAS. SWINBURNE.

Chelmsford.

ANIMAL ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I observed your note in *The Electrician* of the 5th inst. respecting "Animal Electricity." I shall feel personally very much obliged if you or any of your correspondents can tell me what "animal electricity" is (practically), and its *modus operandi*. Can Mr. Barham tell me? If so he will confer a favour on—Yours, &c., PARALYSIS.

37, Park Cross-street, Leeds, Feb. 12th.

INSURANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am obliged for the answers to my letter which were published in your last issue.

From "R.I.S.K.'s" letter I gather that at least *one* other engaged in the electrical profession has received very strange treatment at the hands of an insurance company, and I think it is a pity that the name of the company was not published, so that it might save us the trouble of applying, in our ignorance, to them for protection. I say nothing of the want of knowledge on the part of the insurance company in refusing to accept the risks of electrical engineers.

It is some satisfaction, however, to find two letters from the manager and secretary respectively of insurance companies, stating that they are willing to take electrical engineers, but, it appears, on very different terms.

In the case of the Scottish Economic, we are placed in Class III., or "Hazardous" risks; but on inquiry at the Imperial Union Offices, in Finsbury-pavement, I find they are willing to accept *bonâ fide* electrical engineers on the same terms as civil engineers, in Class II. This company seems to have come to the sensible conclusion that the knowledge which electrical engineers have of the power of their machines and consequent danger (where any exists) tends to lessen their liability to accidents. It is, I believe, the same with civil engineers, for it must be confessed that they often have very dangerous work to perform in testing and examining bridges, foundations, machinery, &c., but owing to their *special*

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knowledge of the dangers that exist they are considered as only liable to "medium risks."

I do not think it is necessary now to join together in order to take some concerted action, as "R.I.S.K." suggests, for to my mind the insurance question of electrical engineers is fairly solved by the information we have now gained that they will be accepted by one company at least as "medium risks," and classed with civil engineers.

My object having now been obtained, I beg to thank you for inserting my letter, and the other gentlemen who so readily answered it.—Yours, &c., INSURANCE.

London, E.C., Feb. 17, 1886.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My letter to you of 21st December last contained a statement of the fact that the boy did not feel a shock when he communicated one to another person. Dr. Stone took no notice of this in his first letter, but perpetrated the insinuation that I had been deceived, by his insinuating that the source of electricity was the action of the boy's feet on the carpet. In my letter of 9th January I especially recalled Dr. Stone's attention to the above-mentioned new fact, but no reply came from Dr. Stone. Instead thereof "Hamlet's" letter came, containing manifestly false statements with the intention of casting ridicule on the whole subject. In my letter of 30th January I gave the proof that it was impossible I could have been deceived (as insinuated by Dr. Stone and his shadow "Hamlet"), because my own faculties informed me that the electricity was not distributed over the surface of the boys' body, as it always was in my experience when I electrified persons by means of electricity from an external source. In Dr. Stone's letter of the 12th curt. he makes no reply to this proof, but proceeds to ridicule my statement that the air we breathe is a source of electricity within our bodies. His doing so only proves that he has not in his mind the facts wherewith to form an opinion on this subject. I shall therefore, with your leave, supply this defect.

The atmosphere we breathe consists of nitrogen, oxygen, and ozone, all of which contain their normal quantities of latent electricity, and when they enter the lungs they come in contact with the carbonaceous matter which consumes them. The internal heat of our bodies is thereby produced and kept up. Now, wherever there is combustion, the normal electricity contained in the bodies consumed is set free, and it takes up a new position by becoming latent either in the newly-combined substances, or it passes into the surrounding matter, as manifested in the flashes of lightning which often accompany the bursting forth of the great fires of volcanic eruptions. That which men and animals expire from their lungs is carbonic acid gas and the vapour of water. Here the question arises, Do these substances contain all the electricity which was taken into the lungs by the nitrogen, oxygen, and ozone inspired? If not, then a portion of the latent electricity of the nitrogen, oxygen, and ozone inspired must go into the blood and tissues of the body, and thence go to the skin and pass through it either as free electricity, like the lightning of the volcano, or become latent in the perspiration and pass off silently and unobserved by man.

In your notes of last week's number you drew attention, Sir, to the cases of the electric bug and electric cow. The particulars of the latter are contained in Volume V. of *The Electrician*, page 85. For my purpose I quote therefrom only the following facts:—"Mr. Woods, veterinary surgeon, at Wigan, was called, on 21st February, 1880, to examine a cow which had given birth to a calf, which circumstance had so deranged the cow's system that she had become charged with free electricity to such an extent that every person who touched her received a powerful shock of electricity. Mr. Woods administered to the cow powerful doses of opening medicine, and on the day following this all the appearances of free electricity disappeared from the cow's body." There is only one way in which this opening medicine could have had this effect, namely, by opening the pores in the cow's skin, and thereby restoring to her the power of perspiring in the normal manner, and then the electricity became latent in the perspiration, and was carried off insensibly.

The foregoing proof I consider sufficient for my present purpose, but, if necessary, I could give further proof that all the latent electricity carried with our breath into our lungs is not expired, and must find vent as free electricity on the surface of the skin, or disappear insensibly as latent electricity in the perspiration.—Yours, &c., JAMES JOHNSTONE.

8, Merchiston Park, Edinburgh, February 15th, 1886.

N.B.—In this letter I have used the word "latent" advisedly, because I have no sympathy with the delusion that electricity is "energy."

[We must endeavour to assure Mr. Johnstone that "Dr. Stone" and "Hamlet" are different individuals, unknown personally to each other, and resident the length of England apart. "Hamlet" assures us that he knew the man who exhibited the boy, and that electrical apparatus was used to produce the phenomena.—ED. *E.*]

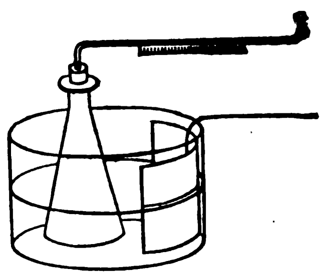
EVIDENCE RESPECTING THE REALITY OF "TRANSFER RESISTANCE" in ELECTROLYTIC CELLS.*

BY G. GORE, LL.D., F.R.S.

In a paper published in the *Proceedings* of the Royal Society, 1885, No. 236, Vol. 38, p. 209, I have stated that "a species of electric resistance, distinct from that of polarisation and ordinary conduction resistance, varying greatly in amount in different cases, exists at the surfaces of mutual contact of metals and liquids in electrolytic and voltaic cells," and "this resistance varies largely in amount with different metals in the same solution, and with the same metal in different solutions."

As conduction resistance is attended by evolution of heat, I took advantage of this fact to search for a difference of temperature produced by "transfer resistance" at the surfaces of different metals in the same solution, and I now employ the same fact in a somewhat different way to search for difference of heat evolved at the surface of the same metal in different liquids. I use an air thermometer instead of mercurial ones, and make an experiment like that of Peltier's, but employing a metal and electrolyte instead of two metals.

I took a thin platinum bottle, of a conical shape, of 10·0 cm. total height; 5·0 cm. in diameter at the bottom, and 1·25 cm. diameter at a height of 8·5 cm., at the bottom of the neck. It had a slightly concave bottom, and was placed in a flat-bottomed glass basin 12·0 cm. in diameter. It was closed air-tight by a perforated india-rubber bung, having a narrow horizontal glass tube, open at both ends, fixed in it. The tube had an internal diameter of about 2·0 mm.; it was provided with a small divided scale, and contained a minute drop of water to act as an index of the expansion or contraction of the enclosed air (see sketch).



After ballasting the bottle by means of a heavy ring of glass encircling its neck, the electrolyte was poured into the glass basin up to a height of 3·0 cm. A sheet of platinum 8·0 cm. × 15·5 cm. with its largest dimension horizontal, was placed vertically in the liquid to act as an anode. Under these circumstances, the amount of external surface of the platinum bottle in contact with the liquid, excluding that of the bottom,

* Read before the Royal Society January 21st, 1886.

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was about 40·0 square centimetres, whilst that of the front side of the sheet of metal was about 46·5 sq. cm. These several conditions, and the distance of the sheet from the bottle, were kept the same in each experiment.

In some preliminary trials, using a current from a battery of six pairs of zinc and platinum in dilute sulphuric acid, in single series, and a large anode of zinc instead of the platinum one, on passing the current through a mixture of one volume of sulphuric acid and one hundred of water, into the bottle, whilst much hydrogen was evolved at the cathode, a small expansion of the air in the bottle at once occurred, and moved the index forward 1·0 mm. in about two or three seconds. The current was then stopped, and the index returned to its former position in about one minute. The piece of zinc was then replaced by a platinum wire which was brought into contact with the bottom of the bottle, and the circuit again closed. The current now circulating was about the same in strength as before, and none of it appeared to pass through the liquid; but notwithstanding no cooling influence by evolution of hydrogen now operated, there was no visible movement of the index or expansion of air in the bottle. This experiment of passing the current alternately through the liquid and through the bottle was repeated a number of times, and the same results respectively obtained. With nitric acid diluted in the same proportion, instead of the sulphuric acid, the effects were similar but a little more conspicuous, probably because the resistance was greater, and a portion of the hydrogen was oxidised.

As when the current passed through the liquid certain amounts of heat must have been absorbed by the liberation of hydrogen, and by that substance assuming the gaseous state, each at the surface of the bottle, and notwithstanding these cooling influences, the temperature of the bottle rose, an amount of heat more than sufficient to compensate for these losses must have been produced by the current. What was the source of this heat? Was it due to ordinary conduction resistance in the mass of the electrodes or liquid, or to some action at the surface of the bottle? As the index did not suddenly advance when the current was passed through the bottle only, the heat was not due to ordinary conduction-resistance of that vessel, and whatever the amount of heat produced by such resistance was, it must have been very small in comparison with that which produced the expansion. As the expansion was sudden, it could not have been due to resistance of any kind at the anode. And as the temperature of the bottle rose suddenly and fell quickly, and the mass and specific heat of the liquid were each considerable, it could not have been produced by heat of conduction-resistance of the liquid. The sudden expansion was therefore probably due to some influence, other than that of chemical change, acting at the surfaces of mutual contact of the liquid and bottle.

The influence of difference of liquid with currents of equal strength was also tried, the electrolytes consisting of (1st) a mixture of one volume of strong sulphuric acid and ten of water, and (2nd) of ordinary concentrated nitric acid for the purpose of preventing the evolution of free hydrogen. The current was from six Grove cells in single series, and its strength in each case was = ·454 ampere; it was stopped in each instance after a few seconds (whilst the expansion was increasing, though at a diminished rate), in order to exclude as much as possible the influence of heat of conduction-resistance of the liquid. The anode of sheet platinum was used in each case.

With the dilute sulphuric acid the expansion was = 3·0 mm. in two seconds, and on then stopping the current the contraction was 1·0 mm. in three seconds. Hydrogen was freely evolved. Increasing the density of the current by raising the bottle partly out of the liquid increased the rate of expansion, and decreased that of contraction.

With the strong nitric acid the expansion was 1·0 mm. in three seconds, and on then stopping the current a contraction occurred of about ·2 mm. in three seconds. No gas was evolved at the cathode. Increasing the density of the current in the above manner had but little effect. By passing the same strength of current up through the flask by means of a platinum wire in contact with the bottom of the bottle, an expansion of only ·5 mm. was produced in ten seconds.

The larger expansion with the dilute sulphuric acid than with the strong nitric acid, notwithstanding the cooling influence of the evolved and gaseous hydrogen in the former case, was probably due to a greater resistance of some kind at the surface of the bottle in the former than in the latter liquid. If this conclusion is correct, the heat produced by such resistance at the platinum cathode in dilute sulphuric acid was greater than that absorbed by the liberation and assumption of the gaseous state of the hydrogen in that liquid, and also greater than that evolved by such resistance in strong nitric acid. The small amount and slowness of expansion occurring when the current was passed up the flask, showed that the sudden expansion was not due to heat of conduction-resistance of that vessel.

In another experiment with dilute sulphuric acid, one volume of strong acid to ten of water, and a current of ·336 ampere, the expansion was 3.mm. in two seconds; and on then stopping the current, the contraction was 1·0 mm. in thirty seconds. And with nearly concentrated nitric acid, and a current of ·084 ampere, the expansion was 1·0 mm. in three seconds, and by then stopping the current, a trace of contraction in thirty seconds. Of course, in every one of the experiments, the amount of expansion shown by the index was less than the total, because the bottle itself expanded as well as the air in it.

If the sudden expansion in these cases was really due to some "resistance" at the surface of the bottle, it ought to vary directly with it. In order to test this point, the amounts of such "resistance" at the surface of the bottle when used as a cathode were carefully measured whilst a current of ·454 ampere was passing. That in the dilute sulphuric acid (one to ten) equalled 3·41 ohms; whilst that in the strong nitric acid was ·17 ohm, or $\frac{1}{20}$th the former amount. The amount of "resistance," therefore, at the surface of the bottle in the two liquids varied directly as the heat evolved and expansion produced. As the liquids were not stirred, the "resistances" measured included that due to polarisation, and its counter-electromotive force. As I had already in many cases found large differences of "resistance" at the surfaces of the same metal in different electrolytes, whilst the latter was being rapidly stirred in order to prevent polarisation, I did not repeat these experiments under the additional condition of stirring.

Separate experiments were carefully made to measure any alterations of temperature occurring in the mass of the liquids during the passage of the current of ·454 ampere through them, under exactly the above conditions; the thermometer employed being capable of indicating one-fiftieth of a centigrade degree. With the dilute sulphuric acid (1 to 10), and with the strong nitric acid, no perceptible alteration of temperature took place, even by continuing the current during three minutes. This fact agrees with the circumstance observed, that in each of these liquids, on stopping the current, the bottle cooled quickly; but had its heat been derived from the mass of the liquid this would not have happened. The absence of change of temperature in the dilute sulphuric acid is consistent with the inference that the heat produced by the resistance of the liquid, and that produced by surface "resistance" at the anode and cathode, and imparted to the liquid, was exactly neutralised by that absorbed by the chemical changes at the electrodes. In the strong nitric acid the circumstances were somewhat different, although the final result was similar. In that case, both the amount of heat of conduction-resistance of the liquid, and that of "resistance" at the electrodes was comparatively small, and the portion of heat absorbed by chemical action was also small, and these two quantities neutralised each other.

The surface "resistances" were measured by means of a Wheatstone slide-wire bridge, one terminal of a low resistance galvanometer being connected with the slider, and the other connected, first to the cathode and then to a platinum wire (idle electrode) close to the cathode, but not touching it, in the liquid; a balance being obtained in each case by moving the slider.

Additional Experiments.

In these further experiments the same arrangement and electrodes of platinum were used, and the temperature and

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depth of liquid were the same as before, but the bottle was now employed as the anode.

With the mixture of one volume of sulphuric acid and ten of water, at atmospheric temperature as in the preceding experiments, and a current of ·454 ampere, an expansion of 1·0mm. in three seconds took place, and on then stopping the current a contraction of ·5mm. in five seconds occurred. The amount of surface-resistance at the anode, including that due to polarisation, was = 1·03 ohm. There was no perceptible rise of temperature during the ten minutes occupied in making these measurements. Much gas was of course set free at each electrode.

On comparing these results with those of the previous experiment in which the bottle was used as the cathode in this liquid, it may be perceived that the amount of expansion varied directly with that of surface-resistance, each being about three times greater with the bottle as the cathode than with it as the anode.

In another experiment, using the strong nitric acid, and the same strength of current, an expansion of 2·0 mm. took place in three seconds, and on then stopping the current, a contraction of 1·0 mm. occurred in five seconds. The amount of surface-resistance at the anode, including that due to polarisation, was = 1·4 ohm. Much gas was of course set free at the anode, but none at the cathode.

On comparing these results with the previous ones obtained with the bottle as a cathode in this liquid, the amount of expansion is again found to vary directly as that of surface-resistance. In this case, however, the resistance at the anode was considerably larger than that at the cathode; as with *very dilute* nitric acid I have found an opposite effect to this, it is probable that with a certain strength of acid the amounts of such resistance at the two electrodes would be equal; the dilute acid, however, was stirred.

Of course, when the object is to make measurements of all the elements of these phenomena we should have to consider the amounts of heat evolved and absorbed by chemical change and by alterations of physical state; differences of specific heat, changes of temperature caused by convection and conduction of heat, alterations of the amount of effective surface of the electrodes by accumulation of gas, conduction-resistance of the layer of liquid beneath the gas, and of the products of electrolysis adhering to the electrodes, the influence of polarisation, &c., and all this would require an extensive investigation; but in the present case, where only the general effect was sought, and the chief source of expansion was heat of surface-resistance, measurements of the smaller elements of the phenomena were unnecessary.

ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 274.)

*Korteweg's Theory.**

According to this theory, the forces between two elements of current are the same as in Stefan's theory. Korteweg, however, considers in addition the couples which one element may produce on another. If we use the notation we adopted in discussing Stefan's theory, we have, considering the force on ds_2, a force

$$\frac{1}{r^2}\left\{ a\,\alpha_1\,\alpha_2 + b\,\beta_1\,\beta_2 \right\}$$

along the line joining the elements, and a force

$$\frac{1}{r^2}\left\{ c\,\alpha_1\,\beta_2 + d\,\alpha_2\,\beta_1 \right\}$$

parallel to the axis of y.

In addition to these forces, Korteweg supposes that from the action of α_1 on β_2, there is a couple whose axis is parallel to the axis of z equal to

$$f\,\alpha_1\,\beta_2,$$

* "Crelle," XC., p. 49, 1881.

from the action of β_1 on α_2 there is a couple on α_2 whose axis is parallel to the axis of z, and equal to

$$g\,\beta_1\,\alpha_2,$$

and from the action of α_1 on γ_2, a couple on γ_2 whose axis is parallel to the axis of y, and equal to

$$-f\,\alpha_1\,\gamma_2;$$

and from the action of β_1 on γ_2, there is a couple on γ_2 whose axis is parallel to the line joining the elements, and equal to

$$h\,\beta_1\,\alpha_2.$$

If we now take arbitrary co-ordinate axes, the forces on the element ds_2 are the same as those given by Stefan's theory. The couples, however, are different; the component parallel to the axis of x of the couple on ds_2 is given by the equation

$$\begin{aligned} \mathrm{L} = \Bigg[& \frac{d}{r^2}\frac{dr}{ds_2}\left(y\frac{dz}{ds_1} - z\frac{dy}{ds_1}\right) - \frac{a-d-c}{r^3}\frac{dr}{ds_2}\frac{dr}{ds}(y^1z - z^1y) \\ & - \frac{b}{r^2}\frac{d^2r}{ds_1\,ds_2}(y^1z - z^1y) - \frac{c}{r^2}\frac{dr}{ds_1}\left(z\frac{dy^1}{ds_2} - y\frac{dz_1}{ds_2}\right) \\ & + \left(\frac{h+g}{r}\right)\frac{dr}{ds_1}\left\{ (y^1-y)\frac{dz_1}{ds_2} - (z^1-z)\frac{dy^1}{ds_2} \right\} \\ & + \frac{h-f}{r}\frac{dr}{ds_2}\left\{ (y^1-y)\frac{dz}{ds_1} - (z^1-z)\frac{dy}{ds_1} \right\} \\ & - h\left\{ \frac{dy^1}{ds_2}\frac{dz}{ds_1} - \frac{dy}{ds_1}\frac{dz}{ds_2} \right\} \Bigg] i\,i\,ds_1\,ds_2 \end{aligned}$$

with similar expressions for the components of couple around the axes of y and z.

By making the force between two closed circuits have the same value as that given by Ampère's theory, Korteweg finds that

$$a + 2b - d - c = -3\mathrm{A}^2$$

where A is a constant quantity whose value depends upon the unit of current adopted.

By making the couples produced by one closed circuit on another have the same value as that given by Ampère and the potential theory, he finds that

$$\frac{d}{dr}(r^2 h) + (g-h)\,r - c + 2\mathrm{A}^2 = 0.$$

Korteweg considers that the experiments of v. Ettingshausen, quoted above, prove (1) that the force on an element of circuit produced by a closed circuit is at right angles to the element, and (2) that the couple on an element due to a closed circuit has the value given by Ampère's theory; the first condition gives

$$c - b = 2\mathrm{A}^2,$$

the second, the two conditions

$$\frac{d}{dr}(rh) - f = 0$$

$$h + g = 0,$$

and he points out that we cannot get any more conditions by considering the action between two closed circuits or the action of a closed circuit on an element of another. It should be noticed that since, according to this theory, part of the action of one element of a circuit on another consists of a couple, the condition that the force due to a closed circuit on an element of another should be at right angles to the element is not, as in Stefan's theory, identical with the condition that the expression for the couple exerted by one closed circuit on another should be the same as that given by Ampère.

This theory is valuable because it is the most general one of the class we are considering which has been published. It is the only one which takes into account the couples, and by giving special values to the quantities a, b, c, d, f, g, h, we can get any of the other theories of this class.

On the theories which explain the action of currents by assuming that the forces between two electrified bodies depend upon the velocities and accelerations of the bodies.

According to these theories a body conveying an electric current contains equal quantities of positive and negative electricity, so that it will not exert any ordinary electrostatic

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effect. The positive electricity is supposed, however, to be moving differently from the negative. In some of the theories (Weber's, Gauss's, Riemann's) Fechner's hypothesis, that the electric current consists of positive electricity moving in one direction (the direction of the current), and an equal quantity of negative electricity moving at the same speed in the opposite direction, is assumed; in other theories (Clausius') only one of the electricities is supposed to move, the other remains at rest. We see in a general way how the assumption that the forces between two electrified particles depend on the velocities and the acclerations of the particles can explain the effects produced by an electric current.

Let us take first the mechanical action between two circuits A and B, and let us consider the action of an element (a) of A on an element (b) of B. We shall consider first the action of the two electricities which are flowing through a on the positive electricity which is flowing through b. Since the motion of the positive electricity in a relative to that of the positive electricity in b is not the same as the motion of the negative electricity in a relative to that of the positive in b, the forces due to the positive and negative electricities in a will not counterbalance, so that there will be a resultant force on the positive electricity in b depending on the inequality between the motion of the positive and negative electricities in a relative to that of the positive in b. Similarly there will be a force on the negative electricity in b depending on the inequality between the velocities of the positive and negative electricities in a relative to that of the negative in b, and, except for special laws of force and special values of the velocities of the electricities in b, this force will not be equal and opposite to the force on the positive electricity in b, so that a mechanical force on b will be produced by the currents through a.

Let us now consider how inductive forces can be explained by this hypothesis; let us suppose that the element a is moving, and that the element b is at rest. The velocity of the electricity in a will be the resultant of the velocity with which the electricity flows through a and the velocity of translation of a itself, so that since the velocities of flow of the positive and negative electricities are different, the actual velocity of the positive electricity will differ in magnitude from the velocity of the negative (unless, assuming Fechner's hypothesis, the element a is moving at right angles to itself); thus the force due to the positive electricity in a on a unit of positive electricity at b will not be equal and opposite to that due to the negative electricity in a, and thus there will be an E.M.F. at b due to the motion of a. This explains induction due to the motion of the primary circuit.

Let us now consider induction due to the variation of the intensity of the current in the primary circuit. According to all the theories there is a force produced by a moving electrified body proportional to the first power of the acceleration of that body. Let us consider the elements a and b again, and suppose that a variable current is flowing through a and no current through b; then if we suppose that a variation in the intensity of a current is accompanied by an alteration in the velocity of flow, the acceleration of the positive electricity will, if we take Fechner's hypothesis, be equal and opposite to that of the negative; but since there is a part of the force due to the moving electrified body which changes sign both with the electrification and the acceleration, the force due to the acceleration of the positive electricity will be equal in all respects to that due to the acceleration of the negative, so that there will be a resultant force on a unit of positive electricity at b, and this force is the electromotive intensity at b due to the alteration of the intensity of the current in a. In this way we can explain the induction due to the variation of the current in the primary circuit.

Theories of this kind have been given by Gauss, Weber, Riemann, and Clausius, and these writers have given expressions for the force between two electrified particles moving in any way. We shall afterwards consider these expressions in detail, but we may remark in passing that the theories of Gauss, Weber, and Riemann have much in common; among other things they all lead to impossible results. In addition, Clausius has shown that, unless we make Fechner's hypothesis about a current, viz., that it consists of equal quantities of positive and negative electricity moving with equal speeds in opposite directions, a current would on these theories exert a force on an electrified body at rest.

The question of the forces due to moving electrified bodies is interesting in connection with electrolysis. Taking the ordinary view that the current is carried by the ions, we know from Hittorf's researches that the anion and the cation move at different rates, so that the forces produced by these will be different; hence we should expect an electrolyte conveying a current to exert a force on a charged particle at rest.

We shall now go on to consider the various theories separately.

*Gauss's Theory.**

Gauss assumes that the force between two particles separated by a distance r and charged with quantities of electricity e and e' is along the line joining the particles and equal to

$$\frac{ee'}{r^2}\left\{1+\frac{1}{c^2}\left\{u^2-\frac{3}{2}\left(\frac{dr}{dt}\right)^2\right\}\right\}$$

where u is the relative velocity of the two particles and c is a constant. This law will, if we make Fechner's hypothesis, explain the mechanical force between two circuits; but, since it contains no term depending on the acceleration, cannot explain the E.M.F. produced by the variation of the strength of the current in the primary; it is also inconsistent with the principle of conservation of energy, and so we need not consider it any further.

W. E. Weber's Theory.†

Weber assumes that the force between two charged particles, using the same notation as before is

$$\frac{ee'}{r^2}\left\{1+\frac{1}{c^2}\left(r\frac{d^2r}{dt^2}-\frac{1}{2}\left(\frac{dr}{dt}\right)^2\right)\right\}$$

This formula is not inconsistent with the principle of the conservation of energy; making Fechner's hypothesis, it will explain the mechanical force between circuits conveying currents; it will also explain induction due both to the motion of the primary and the alteration in the strength of the current in the primary. We shall, see, however, that it makes a body under certain circumstances behave as if its mass were negative—*i.e.*, if it were acted on by a force in a direction opposite to that in which it is moving, its velocity would continually increase.

Riemann's Theory.

This is explained in his "Schwere Electricität und Magnetismus," edited by Hallendorff, p. 327. According to this theory the force between two electrified bodies is not altogether along the line joining them, but consists of the following parts:—

1. A force along the line joining the particles equal with the same notation as before to

$$\frac{ee'}{r^2}\left\{1+\frac{u^2}{c^2}\right\}$$

2. A force on the first particle parallel to its velocity relative to the second equal to

$$-\frac{2ee'}{c^2r^2}u\frac{dr}{dt}.$$

3. A force on the first particle parallel to this acceleration relative to the second equal to

$$\frac{2ee'}{c^2r}f,$$

where f is the relative acceleration of the particles.

* Gauss's theory was published after his death in his collected works, Gottingen edition, Vol. V. p. 616. See also Maxwell's "Electricity and Magnetism," 2nd edit. Vol. II. p. 440.

† Weber's theory was published in 1846 in *Abhandlungen der Königlich-Sächsischen Gesellschaft der Wissenschaften*, 1846, p. 211; it is reprinted in *Electrodynamische Maassbestimmungen*, 1871. A good account of the theory is given in Maxwell's "Electricity and Magnetism," 2nd edit. Vol. II. Chap. XXIII.

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There are, of course, similar forces acting on the second particles, and we see from the form of the expressions of the forces that the force on the first particle is equal and opposite to the force on the second. Riemann's law of force is not inconsistent with the principle of the conservation of energy, and it explains the mechanical force between two circuits ; hence it must explain the induction of currents. We shall see, however, that it is open to the same objection as Weber's theory, viz., that it makes an electrified particle under certain circumstances behave as if its mass were negative.

*Clausius' Theory.**

If x, y, z are the co-ordinates of the first electrified particle, x', y', z' those of the second, then according to this theory the x component of the force on the first particle is equal to

$$-ee'\left[\frac{d}{dx}\left\{(1-vv'\cos\epsilon/c^2)\frac{1}{r}\right\}-\frac{1}{c^2}\frac{d}{dt}\left(\frac{1}{r}\frac{dx'}{dt}\right)\right]$$

With similar expressions for the components parallel to y and z, here v and v' are the velocities of the first and second particles respectively, and ϵ is the angle between their directions of motion. We may analyse these forces a little differently, and say that the force on the first particle consists of—

1. A force along the line joining the particles equal to

$$\frac{ee'}{r^2}\left\{1-vv'\cos\epsilon/c^2\right\}$$

2. A force parallel to the velocity of the *second* particle and equal to

$$\frac{ee'}{c^2r^2}\frac{dr}{dt}v'.$$

3. A force parallel to the acceleration of the *second* particle equal to

$$-\frac{ee'}{c^2r}\frac{dv'}{dt}.$$

We have, of course, corresponding expressions for the force on the second particle.

Clausius's formulæ differ from those of Gauss, Weber, and Riemann in two very important respects.

1. They make the forces between. two electrified bodies depend on the absolute velocities and accelerations of the bodies, while the others make them depend only on the relative velocities and accelerations.

2. They do not make the forces between the bodies equal and opposite, so that the momentum of the system does not remain constant.

These results show that if this theory is true, we must take the ether surrounding the bodies into account. The first result can then be explained by supposing that the velocities which enter into the formulæ are the velocities of the bodies relatively to the ether at a considerable distance from the bodies, and the second result by supposing that the ether possesses a finite density, and that the momentum lost or gained by the bodies is added to or taken from the surrounding ether.

The case is analogous to the case of two spheres, A and B, moving an incompressible fluid ; in this case the forces on the sphere A depend on the velocities and acclerations of B relatively to the fluid a great distance from the sphere, and are independent of the velocity and acceleration of A ; the forces are not equal and opposite, and the momentum lost or gained by the system is added to or taken from the momentum of the fluid. At the end of this section we shall see that if we assume that variations in what Maxwell calls the electric displacement produce effects analogous to those produced by ordinary conduction currents, we get the same forces between moving electrified bodies as are given by Clausius's theory.

Clausius's theory is not inconsistent with the principle of the conservation of energy, and we shall see that it does not lead to the same difficulty as the theories of Weber and Riemann, viz., that under special circumstances a body would behave as if its mass were negative.

* This theory is given in "Crelle," Vol. 82, p. 85. There is also a full abstract in Wiedemann's *Beiblätter*, Vol. I. p. 145.

Assuming that in an electric current we have equal quantities of positive and negative electricity moving with different velocities, Clausius has shown in the paper already cited that his theory gives Ampère's results for the mechanical force between two circuits, and the usual expression for the induction due to the motion of the primary circuit, or variation in the strength of the current passing through it.

Fröhlich* urges against Clausius's law that since, according to it, an electric current in motion exerts an electromotive force on a moving electrified particle, even though the particle is moving at the same rate as the circuit, every current on the earth's surface ought to exert an electromotive force on an electrified particle relatively at rest, since each is moving with the velocity of the earth. This force is one that can be derived from a potential, so that the integral of the force taken round a closed curve would vanish, and thus, even if this result were true, two circuits would not induce current in each other if they were relatively at rest. Budde† points out, however, that the moving circuit would exert an electromotive force at each point of itself, and thus cause a separation of the electricity in the circuit, so that it would get coated with a distribution of electricity, the electrostatic action of which would balance that due to the action due to its motion on a point relatively at rest. The velocities which enter into Clausius's formulæ are velocities relative to the ether, so that if the ether moves with the earth, an electric current will, according even to this theory, exert no electromotive force on a point relatively at rest, and there will be no electrification on the surface of the circuit. The velocity c which occurs in all these theories is a velocity comparable with the velocity of light.

(To be continued.)

SOME POINTS IN ELECTRICAL DISTRIBUTION.‡

BY PROF. GEORGE FORBES, M.A., F.R.S.E.

When I had the honour, just a year ago, to give a course of Cantor Lectures to this society, on the distribution of electricity, the subject had not till then been treated in a systematic manner. I had then occasion to speak in strong terms of some of the methods then habitually adopted, and subsequent experience has confirmed me in the justness of my criticisms.

I gave a fairly complete account of the practical systems of laying electric mains, which were at the diposal of the engineer when designing a system of distribution ; but in the course of only three lectures it was impossible to do justice equally to all systems. When I was this year asked to give a lecture to the society, I eagerly availed myself of the opportunity to take up the straggling threads, and say a few words on the subjects which were previously but inadequately treated of.

Allow me to remind you that, in my lectures, I described five different ways of laying the mains, each one depending upon a different method of connecting the dynamo machines and lamps. Three of these may be called direct systems, and two indirect. Each system has special advantages when applied in suitable cases, and when an engineer is designing a scheme of distribution he carefully considers the *pros* and *cons* of each system as applied to the special case, and very often he has to go through the whole calculations of the scheme according to several different systems. And here let me repeat, what I have often stated before, that no amount of labour and expense in these preliminary calculations should be grudged, as the ultimate saving effected by the careful selection of a suitable and economical system may easily range to 100 per cent. or more on the total cost of the installation. The three direct systems are the parallel, series, and parallel-series methods of attaching lamps to the main conductors.§ The two indirect systems are with the use of secondary batteries and secondary generators. Each of these systems is capable of being varied in the details of its application, and each is specially applicable to particular cases. In a parallel system each lamp is attached by wires to the two main conductors, and thus to the two terminals of the dynamo. This is its characteristic feature, viz., that the lamps are all metalically connected with the terminals of the machines. In the series system, the conductor going through the district has its two ends connected one to each pole of the dynamo. But wherever there is a lamp the conductor is severed, and each terminal of the lamp is attached to one of the severed ends. In the parallel series arrangement the district is divided into sections. The first section and the last section have each a conductor attached to one terminal of the dynamo. The other conductor of the first section extends also through the second se-

* Fröhlich, *Wied. Ann.* IX. p. 277, 1880.

† *Wied. Ann.*, X. p. 553, 1880.

‡ Paper read at the Society of Arts, Wednesday, February 17, Prof. W. Grylls Adams, F.R.S., in the chair.

§ In my Cantor Lectures I used the terms multiple arc, series, and multiple series. I prefer the terms now advocated.

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tion but no farther. Another conductor extends through the second and third sections, another through the third and fourth, and so on. In each section the two wires from each lamp are attached to the two conductors of that section. The first or parallel system is generally most suitable for small installations ; but the cost of conductors becomes extravagant when the area is extended, except in very special cases. The series system is at present only used for arc lights, sometimes with the insertion of a few glow lamps to replace an arc lamp.

The third system is admirably suited in every case where the number of lamps in use at any time is constant, and may perhaps be modified so as to be applicable to other cases. Smaller conductors can be used on this system than on the first, and this effects a very great economy. Having recalled these points to your notice, I need say no more, as I treated these three systems and their modifications very fully in my Cantor Lectures.

I thought I had spoken strongly enough about the enormous cost of the main conductors, and the necessity for selecting that size of conductor which is the most economical. We must not use too small a conductor, for then the waste of energy in heating the conductors would be enormous. Nor must we use too large a conductor, for this means buried capital. We must select the size which balances one cause of loss against the other, so as to give the maximum economy. I find, however, that, while this axiom has been accepted as such in this country, some writers from America still try to uphold the fallacious views which have hitherto been in vogue there. I have noticed more than one criticism from America, by people asserting themselves to be connected in some way with some of the Edison companies, who protest against my statement that the three-wire system effects an economy of copper of only 25 per cent. over a two-wire system. The difference between us is that I start with the axiom that we are to use the most economical size of conductor. My critics start with the assumption that they shall use a conductor which shall waste exactly 10 per cent. of the energy. In this way they use a conductor which is not the most economical, and they show a saving of 62½ per cent. of copper over the two-wire system with a possible extra waste of energy of 62½ per cent. I said in my Cantor Lectures, and I repeat it this evening, that this manipulation of figures may suit American financiers, but it is not electrical engineering.

Before proceeding to discuss the indirect methods of distributing electricity, which is the main point I wish to touch upon to-night, I wish to supplement my remarks on series lighting by a statement of what has been done in the last year. I expressed a hope that more attention might be given to the lighting of houses by glow lamps in series. I further showed that it was only by means of a constant current flowing through glow lamps in series that the regulation of each lamp could possibly be effected on economical principles. This regulation must be accomplished by altering the length of the filament in the lamp. This has never yet been done, but if inventors once realise the importance of the object to be attained I feel sure that we shall not have long to wait for the solution of the problem. Now, I am delighted to be able to inform you that during the past year at least one inventor has been applying himself to the placing of glow lamps in series. Mr. Bernstein, who has paid so much attention to the system of glow lamps, has worked out the problem of using lamps of low pressure and large current in series. He has boldly taken extreme measures and proposes using lamps of 6 volts and 10 amperes, or even 2 volts and 30 amperes for larger houses. And here he has got over a difficulty I referred to in my Cantor Lectures. I said that there was no economical way of preventing a broken lamp from extinguishing all the others on the series. Passing part of the current through a shunt whose resistance is 100 times that of the lamp would be very expensive if we had in use lamps of the ordinary type, but with a lamp whose resistance is a fraction of an ohm, the expense would be trifling. When the lamp breaks, the current in the shunt is increased so as to release a contact which short-circuits both the lamp and the shunt. I still think, however, that the loss of energy by heat conduction at the terminals may be very great in lamps of so low a resistance ; Mr. Bernstein tells me it is 10 per cent. Still I can well foresee that, even if a very sensible loss of energy occurred, the economy and convenience of using such a system might be amply sufficient to warrant its adoption in many cases.

I congratulate Mr. Bernstein on his work in the past, and would urge him to develop this idea more fully, and I can assure him that I, for one, will give the fullest consideration to the system when preparing the plans for electric light installations. I should like also to take this opportunity of congratulating other makers of electrical appliances on the advances which have been made since the date of my Cantor Lectures. I should like especially to congratulate Mr. Swan on the improvements he has made in the manufacture of glow lamps ; the Messrs. Siemens and Messrs. Crompton on their successful construction of very large dynamos ; Messrs. Elwell and Parker on their great improvements in the details of construction of dynamos and motors ; and the Electrical Power and Storage Company on the continued improvements in their secondary batteries. I would equally congratulate Messrs. Willans and Crompton for the continued improvements in steam engine governors, for keeping the current from a dynamo or the pressure at any point in the circuit constant ; likewise Mr. Ferranti for having brought out an electric current meter which promises to fulfil all the wants of engineers and the public in this direction ; and last, but by no means least, Messrs. Woodhouse and Rawson for various new devices which will go far to assist in designing and carrying out many schemes of lighting ; and I would specially mention their automatic cut-out, adjustable to any strength of current, which, though not so new as some other devices, has only been brought prominently to my notice during the past year, and whose simplicity and reliability give me great confidence in employing it. I must not fail to include here, as a subject for congratulation, the rising esteem in which secondary generators are held, and the improvements which have been made in their manufacture. When I add to this list the admirable lampholder of Mr. Alfred Swan, Varley's adjustable carbon resistances, and other small but useful accessories, I think you will agree with me that the facilities at the disposal of the engineer for designing a satisfactory scheme of electric lighting, and which have been added to his store during the past year, are very abundant.

About some of these appliances I should like to add a few words.

First, I may say that the Electric Lighting Act was rendered abortive, if for no other reason, simply for the want of an electric current meter which was in all points satisfactory. In the year 1832 a patent was taken out for a meter in which the current passing round an electro-magnet created a field where mercury was placed, which rotated when the current passed through the mercury from the centre to the exterior of the field. If the magnetism be proportional to the current, and the friction be proportional to the square of the velocity, then the number of turns completed in any time is a direct measure of the total quantity of electricity which has flowed through the meter in that time. The marked improvements introduced into this meter by Mr. Ferranti consist in the perfection of the magnetic circuit, and the introduction of an almost frictionless mechanism for correcting the revolutions and showing them on dials like a gas meter.

I have many of these appliances on the table which any member of the audience may examine at the conclusion of the paper. In referring to my Cantor Lectures, let me make a few remarks about a double table which I introduced to assist engineers in calculating the size of mains required in any installation. These tables have been copied into a number of technical journals and books of reference, but in nearly every case there is no word of explanation how to use them. I have found these tables of such paramount convenience that I think it right to call attention to them once more. The economical size of main depends upon three variable factors—the price of laying down a ton of copper mains, the interest to be charged on the capital sunk in mains, and the value of an electrical horse-power for the number of hours that it is to be utilised during the year. My table is divided into two parts. Look along the line in the second part which relates to the percentage on capital which you propose to use, until you come to the column relating to that price of copper which you propose to use, and you then find a number printed which we may call the auxiliary number. Now take the first part of the table and look along the line which relates to that value of a year-horse-power which you propose to use, until you find the auxiliary number ; the heading of that column of figures tells you the size of main per 1,000 amperes which is most economical to use according to the data you have employed.

I will now remind you of the position in which we were left after a full discussion in the Cantor Lectures of the three direct systems of distribution. The parallel system, or the three-wire system, is admirably adapted in cases where the farthest lamp of the district is within two hundred yards of the central station. So soon as you go to greater distances the cost begins to increase in an alarming ratio. Hence this system would be applicable to a large district only by having engines and dynamos put down at a very large number of small stations. Now, a station is not worked economically unless the engine driver and stoker are fully employed, and the maximum economy cannot be reached with less than about 1,000 horse-power. Thus the parallel system is only applicable to cities so densely populated as to have a consumption of about 10,000 16 candle-power lamps in a radius of two hundred yards. But in most districts of this class space is valuable, and a large number of such stations would be very expensive. We must, then, in the parallel system of distribution, be content to work at a cost which is above that of the ideal of economy. There are many cases where the great simplicity of such a system does actually make it worth while to sacrifice this ideal of economy, and when an engineer is consulted on such matters, it is his duty to estimate the exact loss from not strictly following the ideal economical rules before adopting or rejecting this system. In order to make a parallel system effective, the central station must use distributing boxes, the methods of placing which are described in my Cantor Lectures. The cure for all these evils would be found if a thoroughly satisfactory system on the parallel-series plan were known. In that case high tension electricity might be used involving smaller conductors. Thus the central station might be at a distance, where land is cheap, and it might be of any size, so that all the works would be in the same place as they are in gas distribution. Here the only departure from the ideal of economy lies in the length of the conductors to the district which has the supply. But these conductors are comparatively small, and no engineer would recommend the adoption of such a system unless he found that the economy of having the works out of the expensive district exceeded the extra expense in mains.

Now I regret to be compelled to say that, after discussing all the ingenious plans on the parallel series systems proposed by Mr. Edison and others, I arrived at the conclusion that at this time there is no parallel series system of distribution which is quite satisfactory. I do not say that such a system cannot be devised, but I do say that at this moment no such system is available to the electrical engineer, except in the case where the same quantity of electrical energy is consumed in any district at all hours during which the current is being supplied. There are some cases where it will pay to insert equivalent resistances when lamps are put out. These cases are rare, but they must not be lost sight of by the engineer. Having in the Cantor Lectures discussed all the direct systems of distribution, I will complete my outline of this part of the engineer's profession by an examination of the two indirect methods which I formerly touched upon only lightly, viz., secondary batteries and secondary generators.

Secondary Batteries.—During the electric boom (as Americans would call it) of 1882, the secondary battery took a prominent part, not so much for what it had done as from what was expected it would do. It was said that since no one would think of sending gas from the retorts without storing it in a gasholder, so the same must be done with electricity. Every one will admit that it is most desirable that this should be done, and I am glad to say that secondary batteries have been improved to such an extent that there is every reason to hope that this will be done, always

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provided that the companies who supply them do not expect the public to repay them for the hundreds of thousands of pounds which have been thrown away in the past. I have been given to test about a dozen different kinds of secondary batteries, of which I have found some four or five to be good, and the others mostly worthless. I can say this with certainty, that at the present moment secondary batteries can be supplied by certain makers which are to be relied on with careful usage, and which give us 70 to 80 per cent. return for the energy expended.

Now it might be asked what are the advantages of storing the energy if you lose 25 per cent. by doing so? The first advantage is that a breakdown in the machinery does not then interfere with the supply. The second advantage is that the steadiness of the supply does not depend upon the speed of moving machinery. The third and great economical advantage is that your expensive engines and dynamos are paying interest twenty-four hours of the day, instead of only a few hours, by doing their work; and a smaller supply of engines and dynamos suffices. Now this is all very well, so far as having secondary batteries at the point of supply is concerned, but it does not help us much so far in the great problem which we have attacked, viz., that of electrical distribution. But the improvement of secondary batteries led to great hopes of a cheap system of distribution. It was said, "Put your generating station at a distance, on cheap ground, carry a current with high potential through small conductors to the district to be lighted. Pass the current through some thousand accumulators in series, placing these in batches of fifty, say, each, in cellars, to light up a small district." The original idea was to keep the service wires permanently attached to the two ends of each set of fifty cells. Now, this plan is very beautiful if only it would work. But it will not work. The consumption being small from some of the cellars and large from others, and the same charging current going through all of them, the cells must become overcharged in many cases, and this is injurious or not economical.

Another plan was proposed, which I described in my Cantor Lectures. This was to introduce an arrangement to indicate when the cells were fully charged. By having two complete sets of batteries in each cellar, the indicator caused a rocking switch to act which switched the fully charged battery off from the charging mains on to the service mains, and at the same time switched the second set, which had, up to that time, been supplying the service mains on to the charging mains. Here I would point out that, independently of the fact that we have no reliable indicator to show when the cells are fully charged, this only moves the difficulty back one step. For it will often happen that both sets are fully charged, and yet we are obliged to send current through one of them. This plan was tried at Colchester, but of course it had to be abandoned. If we had a true indicator to show when the cells are fully charged, the more sensible plan of using it seems to be to cause the indicator to disconnect the cells from the charging mains and connect the charging mains metallically. There would of course be a great fall of potential in lamps immediately after switching off the supply current, but the charging of the cells might be done by day or after midnight, during which time lamps are not very much used. I think that even this small difficulty might be got over by causing the indicator when it acts to increase the number of cells which lead to the lamps. I suppose the most reliable indicators which could be used are those depending upon the specific gravity of the solution or the weight of the negative (oxydised) plate. Unfortunately it is seldom found that a number of cells working in series become charged at the same time. In fact, it is not very generally known that the most satisfactory plan for charging secondary batteries is to do so in quantity or parallel. When this is done, every cell is fully charged exactly at the same time, and all give off gas at the same moment. If there be any possibility of short-circuiting, however, fusible plugs or other cut-outs must be inserted.*

To have a thoroughly satisfactory installation, it is necessary that the cells may be left in their secluded retreats without attention for long periods. I think I can safely say that cells can be so left if fairly treated. But the question is whether any scheme of distribution hitherto considered does give them fair treatment. If attendants have to be continually going round to inspect cells, this expense must be carefully calculated so far as is possible, and taken into account.

Now let me say a few words as to the improvements in secondary batteries. First, I may say that there is now no doubt that they can be made, are made, by several makers of so good a construction that they can be used for years. I will not fix the number of years, because none of the most perfect ones have yet failed. Secondly, it seems to be conclusively proved that not only does no buckling take place, but there is no fluting or blistering if the plates are originally good, and if the air has has not been allowed to reach them. Thirdly, we know that in overcharging them we do not injure them, but merely waste current. These are important facts, and are all we want for an installation where the state of the cells can be always under examination. For central station lighting we want something more. We want the cells to take current from the dynamos when they require it. For this we must have an indicator on the cells to work a switch, according to the state of charge of the current. Up to the present no satisfactory master-cell has been devised. Those which depend on the gas given off do not act equally promptly with currents of different strength. The most promising system is one in which the state of the cell is shown by the specific gravity of the liquid. Very little ingenuity is required to develop this into a satisfactory system. But we cannot depend upon one master cell since it is only when charging in parallel that all cells act alike. If we have several master-cells in each battery, all of which must act together to cut off the dynamo, I think we might depend upon their action. The probable function of the switch is—first, when the E.M.F. of the battery is too high, to cut out the dynamo circuit from the battery, to give a through connection to the dynamo current, and to switch in two additional cells to the lamp circuit; second, when the E.M.F. of the battery is too low, to break the charging current, to connect the battery to it, and to cut off two cells from the lamp circuit. These are all ordinary things which can easily be done. If such a system were adopted there might be a question with the Board of Trade; but I should have no fear of the result if the work was properly carried out. At present if no better system is introduced we must use high tension currents. But even without automatic action of this sort there are many large installations where it would be economical to use secondary batteries even if attendants had to be continually examining the state of the cells. The engineer who is designing an installation, if he does his duty, calculates the cost of every method of working which can be feasible.

The cost is of course an important item, and were it not that this system introduces a great saving in copper conductors and machinery, it would often be too expensive to work. We may take the cost of batteries at about £3 per lamp of 60 watts. The saving in copper conductors is proportional to the number of batteries put in series. There is also a saving in dynamos and engines. If we take four hours as the average time of using the lamps, we charge them, say, for six hours in the day time, and we use the dynamos as well as the batteries during the greater part of the night. Thus we require batteries and dynamos for only about one-half of the number of lamps generally in use. This brings the cost of batteries down to £1. 10s. per lamp, and the cost of dynamos and engines from about £1 per lamp (the usual cost of a direct service) to 10s. per lamp. This makes a total cost of £2 per lamp, as against £1 by a direct service. When we have made a further reduction for diminished size of conductors, and an increase for additional attendance, we are in a position to compare the two systems. But these figures vary so enormously, that it is impossible to estimate them, unless one has the details before him. We may say safely, however, that in large districts there would be economy in secondary batteries, and in small districts in a direct service. But the advantage of not being dependent on the constant perfection of machinery is very great, and avoids the necessity for so complete a duplication of the parts. Of course, the cost of working must also be made out, allowing for a loss of at least 20 per cent. in transforming through the secondary batteries.

The number of ways of using secondary batteries is great, but there are no engineering difficulties in the distribution, and I may, therefore, content myself with having drawn attention to the general advantages of using them. Among the many special appliances used in this kind of work, I am glad to be able to show you some useful things supplied by the Electrical Power and Storage Company. Perhaps the most important of these is a switch for large currents, in which a number of concentric tubes have a longitudinal slot into which the arm of the switch is forced. The split tubes have a certain amount of spring and literally cut into the arm of the switch, and so make good metallic contact. The one before you has been thoroughly tested with 1,500 amperes passing through it. Another appliance is an automatic switch to reduce the number of cells in the lamp circuit when the dynamo is charging the cells and *vice versâ*. A third is a cut-out to prevent damage to the charging dynamo by an accidental falling off of speed. It has this peculiarity, that it puts the battery in circuit again so soon as the dynamo resumes its functions.

In concluding this part of my subject, I would draw your attention to the scheme of connections for the Vienna Opera House. The dynamos are by Messrs. Crompton, of 72,000 watts, and are driven by direct acting Willans and Robinson engines. I am told that they give an electrical horse-power for 3·7lb. of coal. The secondary batteries are supplied by the Electrical Power and Storage Company. The three-wire system is adopted, 110 cells are ordinarily in use with each circuit, and six additional ones are available to keep the electric pressure constant.

(To be continued.)

LEGAL.

In the Chancery Division on Saturday last Mr. Justice Pearson made an order for the winding up of the British Electric Light Company. The counsel engaged were Mr. M. Cookson, Q.C., and Mr. Ryland for the petitioners; Mr. J. Joyce for the company.

On Wednesday, before Mr. Justice Pearson, Mr. RYLANDS said: I apply *ex parte* for the appointment of a provisional liquidator of the British Electric Light Company. Your lordship made an order for the winding up of this Company on Saturday; but previous to that order being made the landlord had put in a distress for rent, and he has now prepared to sell the effects of the Company to-morrow (Thursday). Under those circumstances it is thought advisable that a provisional liquidator should be appointed, with power to pay the landlord the amount of rent due, if he sees fit. The arrears of rent amount to over £200. The Company consents to this application, and it is considered that it would be the best arrangement for all the creditors.

The JUDGE: I cannot do what you ask.

Mr. RYLANDS: Then will your lordship grant me an interim injunction to prevent the landlord from selling the chattels of the Company?

The JUDGE: Yes; I will grant an injunction restraining him from selling or taking any steps under the distress; and will give you leave to give short notice of motion for Friday.

An order was also made on Saturday, on the application of Mr. N. Lawrence, to continue under the supervision of the Court the voluntary winding up of the International Electric Company.

* Even in this case we may have a partial short circuit, which will drain the current and yet will not cut out the cell.

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COMPANIES' MEETINGS.

Submarine Telegraph Company.

A meeting of the proprietors of this Company was held on Tuesday last, at the offices of the Company, 2, Throgmorton-avenue, London Wall, under the presidency of Sir Julian Goldsmid, Bart., M.P.

The SECRETARY (Mr. S. M. Clare) having read the notice calling the meeting,

The CHAIRMAN, in moving the adoption of the report and accounts, said that he thought the shareholders would say that, on the whole, the report was a satisfactory one. If they had read it, they would have seen in the first place, that, in consequence of the improved condition, especially of the Dutch cables belonging to the Government which they would remember were either partially or completely renewed not along ago, they had had very few breakages in their cables, and the result had been that their ship had been at home for the greater part of the year, and the curious fact resulted from this circumstance that the drawback which was allowed by the insurance office was in excess of the premium they had had to pay, consequently they had paid nothing at all for the insurance of their steamer, and they had a small balance in their favour which would go over to the next half-year's account. In that respect they had nothing to complain of. They had had to repair the Dieppe cable, having had to put into it something over three miles and a half of new line, and they had also had to put one mile and a quarter into the Salcombe cable, which constituted the really important business with regard to repairs that they had had to do, and as both had to be done about the same time, their ship had to leave port only once. He thought this was a matter of congratulation. But when he came to other points he was not quite satisfied. He had told them for some time past what was the condition of their affairs with regard to traffic. He had pointed out that they had had a steady increase in it, and a steady falling off in the length of the messages. He found that whereas for the half-year ended 31st December, 1884, the year before they had 1,428,520 messages. These had increased for the half year ending 31st December, 1885, to 1,490,871, and the words had increased from 17,007,776 in the previous year to 17,062,135 in the year ending December 31st, 1885. The average length of the messages, which was 11·91 words in 1884, had now decreased to 11·44 words, showing that the system of compressing messages was still going on. He had often said, and he repented it now, that he could not tell where the limit of fall in this respect might be. Of course, there was one somewhere, but they had not been able to ascertain it, and he noticed in the returns, with regard to the month of January, which he had been examining, that there was a still further decline from that average of 11·44 words. This was an unsatisfactory side of the question, and he had always thought it his duty to put before the shareholders all the information upon the subject that he reasonably could do, in order that they might have the same advantages as the Directors themselves. It would be observed also that in the report they referred to the Telegraph Conference at Berlin, and he would like to say on behalf of the Board that they considered that Mr. De Bunsen represented their interests at that Conference with great ability. That gentleman belonged to a family of diplomatists who had done a variety of public services, and the Company were very fortunate in having so able a man to represent it as Mr. De Bunsen, for he had done the work extremely well. The alterations in the International scale were comparatively small, and would come into force only on the 1st July next, and would certainly not injure the Company much because the difference which would be created would be very small indeed. He thought this was the sum and substance of their affairs. They had lost one newspaper; but the *Daily News* had leased a wire of three hours a night, in the same way that other papers were in the habit of doing, showing that it was an enormous advantage to the Press to be able to use a wire for their own particular purposes for a certain period during the night. The Submarine Company, therefore, assisted in that way materially to spread information over the whole world. He thought altogether the state of their affairs was satisfactory, and the dividend they were able to recommend a good one, all circumstances considered.

The Right Hon. ROBERT BOURKE, M.P., seconded the motion.

The CHAIRMAN, in reply to a shareholder, said that the Liverpool merchants would have liked to have a special wire—in fact, a special cable laid—to carry their own messages. But two or three years ago the Company and the Post Office investigated the matter, and it was clearly proved that the traffic which the Liverpool merchants afforded was extremely small, and not likely to be enough to remunerate a special wire or cable. As far as any complaint on the part of these gentlemen was ever made, it arose in connection with delays in the land lines and not in the Submarine Company. He was quite certain of this, that if Liverpool could give sufficient business for a special wire, the Company would be quite prepared to co-operate with the Post Office in giving it. He remembered also that some complaint of the same kind was mentioned to them by some of the German authorities, and the Board handed to them the carefully prepared papers on the subject, which were very complete, with the result that those authorities thought the answer so conclusive that they took no further notice of the matter.

The motion was then carried unanimously.

The CHAIRMAN next moved, "That, in accordance with the recommendation of the Court of Directors, a dividend for the half-year ending 31st December, 1885, at the rate of $14\frac{1}{2}$ per cent. per annum, less income-tax, on the capital of the Company, be now declared to become payable on and after the 1st of March next."

The Hon. ASHLEY PONSONBY seconded the motion, which was unanimously adopted, and a vote of thanks having been passed to the Chairman and Directors the proceedings terminated.

The India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

The twenty-second ordinary general meeting of this Company was held at the Cannon-street Hotel on the 18th inst., under the presidency of Mr. Wm. J. Tyler.

The SECRETARY (Mr. S. W. Silver) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: I will at once proceed to move the adoption of the report, and in doing so I think I may allude to what was done on the occasion of our last meeting. It is a great pleasure to us to meet under such circumstances as we have the opportunity of doing to-day. We at our last meeting alluded to the issue of new shares, and I think we may each congratulate ourselves upon the result. The fact of your having supplied us with additional sinews of war will in a measure account for the satisfactory state of things which I hope you feel, with me, we have the opportunity of putting before you to-day. The operations of the year will, I am sure, bear comparison with any undertaking of a similar character. You must bear in mind that competition on all sides is so strong that our difficulty in getting orders is very great, and our difficulty in getting orders to leave anything like a margin of profit is still greater. I do not think I need go into the question of figures, and detain you in so doing. These are a proof of the labours and the close attention on all sides to the interests of the Company. I think they show very fairly as compared with previous years. The result of our net profits this year is within a very little of last year, leaving a disposable balance of £137,547, which, of course, includes the premium upon the new shares, which, as you see by our report, is passed to the reserve fund. After deducting the dividend of £41,000, which is £1 per share, we have a balance to carry forward about the same as last year. As regards the work done, we have connected Cape de Verde with the West Coast of Africa, and sold that cable to the Eastern and Brazilian Companies. We have connected the Portugese and French possessions on the coast of Africa to the extent of 600 miles, and the remaining portion is in process of manufacture, and will be laid towards the close of the year. Now, that is under a guarantee from Portugal of £42,000, and a subsidy from France of £12,000, and a traffic almost half as much as these two amounts together. Besides this, we have manufactured for the Government Indo-European Telegraph Department upwards of 500 miles. Our steamers conveyed the cable to the Persian Gulf, and by their own officers, headed by Sir Henry Mance, that cable has been laid most satisfactorily, our own people being present under the direction of Mr. Theophilus Smith. The whole of this operation has been referred to already in *The Times* of the 25th of last month. I allude to that because it really gives a very satisfactory account of the whole proceeding, and as I think you will agree with me we are not in the habit of blowing our own trumpet, we have in that a very satisfactory report of the manufacture of the cable and of the *employés* connected with the India Rubber Company, as well as the state of our ships. We have executed other orders for the Post Office, India Office, the Western Union Company, and the Western and Brazilian Company, so that in the cable department we have been fairly occupied. With respect to the general state of the works, I may say that electric lighting has not been overlooked by us. Should the time come for a general demand for that most delightful adjunct to our households, we are quite prepared to meet it, and that means that our works are in very excellent order. We are in a position now, I may say, to complete an Atlantic cable under six months—making and laying—and for your satisfaction I may tell you that that item of expenditure upon the works may now be considered to be closed. It will not, I think, be added to much further. Now, all this means that much care and attention have been given by our manager, and by each member of our staff, to the work. This has not been brought about without a great deal of anxious and unceasing care and attention, and at once I am brought to the fact that I occupy the chair to-day in place of one to know whom was to respect him —the late Mr. George Henderson. I fully endorse the words which the report gives utterance to. I may add a little to that by saying that his attention was unceasing. In our anxiety to fill his place we have persuaded Mr. Matthew Gray to take a seat at the Board. (Applause.) I was sure that that would meet with your approval. In him I may say we have the lever, and to him we may attribute much of our success, not only as regards the works—the processes of manufacture—but also in the selection of the *employés* his judgment has been proved again and again to be excellent. Our thanks are certainly due to the members of the staff, and I must not pass over my excellent friend, Mr. Hutchins, our solicitor, whose advice and counsel we have great reason to be thankful for. I do not think I ought to overlook the fact that in laying these cables—the preparation for doing so, the soundings, and so on—Mr. Robert Kaye Gray, Mr. Buchannan, and others on board our steamer, lost no opportunity of adding to the works on physical submarine geography. The reports published by the Government refer especially to the work of the "Dacia," and they are worthy of your notice. At Oxford the other day, in conversation with Prof. Mosley, whose name stands very high in the scientific world, I was very glad to hear that the work was fully recognised, as I know it was, in the hydrographer's office. With these observations I will now move: "That the report and accounts now presented be received and adopted, and that a dividend of £1 per share, free of income-tax, payable on and after the 19th inst., be now declared."

Mr. NEIL BANNATYNE seconded the motion.

Mr. DIXIE referred with deep regret to the death of Mr. Henderson, testifying to the services which that gentleman rendered to the Company. He moved the following resolution: — "That this meeting, having read, with sincere regret, the paragraph in

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the report announcing the death of Mr. George Henderson, desires to express its high appreciation of his personal character and worth, the uniform courtesy and consideration which distinguished him as a Director and Chairman for more than twenty years, and the strenuous efforts made by him in the interests of the Company which have contributed so largely to its development and present success; and this meeting further desires to express its cordial sympathy with his colleagues, and requests that a special message of condolence may be conveyed through the secretary to the widow and members of his family, with a copy of this resolution."

Dr. D. H. SMALL seconded the motion, and said that although he was not always at one with the late Mr. Henderson, he could fully acquiesce in the resolution. He knew that in times of difficulty Mr. Henderson had even made himself personally liable on the part of the Company in connection with money matters.

The CHAIRMAN then put this motion which was carried unanimously.

Mr. SUTCLIFFE wished to know if it was according to the Articles of Association that the Directors should receive 10 per cent. upon the profits in addition to the sum of £2,000. The report must be very satisfactory to every shareholder, and he hoped that the success of the Company would continue, but at the same time it seemed to him that they were paying an excessive amount to the Directors. According to the balance-sheet, the Board received £4,700 or £4,800, giving to each member about £1,200, and he supposed the Managing Director had remuneration besides. It appeared to him that there was a great deal of property invested with continental nations which were not in the highest credit, and he saw that they had received interest from the Spanish National Submarine Telegraph Company of £7,734. He presumed that the capital on which they had received that interest was probably £100,000.

Mr. ANSON referred to the resolution which he proposed a few years ago, regarding the remuneration of the Directors, and stated that the resolution was carried unanimously. He thought it was just that the remuneration of the Board should proceed *pari passu* with the success of the Company—that was, if it were not successful the Directors would receive only so much, while if it were successful they would participate further in that success. They paid the Directors well, and the result of that was seen in the report before them.

Mr. CATLEY asked the value at which the various steamers stood.

Mr. COCHRANE said that some years ago they decided to establish a building as a sort of institute at Silvertown for the workpeople. It was very much desired, and he wished to know what had been done in the matter.

The CHAIRMAN: Mr. Sutcliffe's remarks, as far as the remuneration of the Directors goes, I think, have in a great measure been answered by Mr. Anson; but if you like to have the resolution that was passed read, the secretary will do so.

The SECRETARY read the resolution, and stated that it was passed on the 9th of February, 1881, and was as follows:—"That for the year 1881 and thereafter, subject to revision by the shareholders in general meeting, the ordinary remuneration of the Directors should be £2,000 per annum, and that whenever the shareholders shall receive a dividend of 10 per cent. per annum or more the Directors shall be entitled to receive, by way of additional remuneration, 10 per cent. upon the net profits shown in the accounts for the year in excess of £31,200, being the amount required to pay such a 10 per cent. dividend, but in no year shall the Directors' remuneration exceed £5,000."

Mr. SUTCLIFFE stated that the amount was now considerably more than £31,200.

The CHAIRMAN: So much the worse for the Board; it is spread over a wider surface. I take it now that that is so far answered. As to the reference to the investments—Spanish and Portuguese—we are looking to English companies. The fact that Mr. Sutcliffe alluded to as to the Spanish National Telegraph Company is an answer that the amounts are being paid off regularly, and that line is paying its expenses. To the West Coast of Africa Company that will be a great feeder, and ultimately there will be a very satisfactory return, I believe.

Mr. GRAY said, in reply to Mr. Catley, that the value of the steamers now stood on the books at about 40 per cent. less than they cost, speaking roughly. For instance, one vessel had cost them £115,000, and it stood at £50,000; another cost £45,000, and stood at £30,000, and another had cost £32,000, and stood at £20,000. He therefore thought they were in a pretty healthy condition as far as the value of the steamers was concerned. With regard to the remarks of Mr. Cochrane relative to the proposed institute, he quite endorsed them. All the detailed drawings had been prepared, and the land was ready to receive the building when they were in a position to commence operations. The reason they had not done so before was that they had been so very busy in the erection of their own works, which had required all their attention. The matter, however, had not by any means been lost sight of, and they would proceed with it as soon as they possibly could.

The CHAIRMAN then put the motion for the adoption of the report and accounts, and the payment of the dividend, and it was carried unanimously.

Mr. HENDERSON then acknowledged in feeling terms the resolution of condolence which had been passed in memory of his father.

On the motion of Mr. ABRAHAM SCOTT, seconded by Mr. MATTHEW GRAY, the retiring Directors, Mr. Silver and Mr. Bannatyne, were re-elected.

Mr. KELSO afterwards proposed, and Mr. SINCLAIR seconded a resolution for the re-election of Mr. Weise as auditor of the Company.

An extraordinary meeting was subsequently held, at which the following resolutions were passed *seriatim*, on the motion of the CHAIRMAN, seconded by Mr. BANNATYNE:—

"1. The Board of Directors may from time to time appoint one of their number or any other person to be a Managing Director of the Company, and may determine the amount of his remuneration and the terms of his engagement, but no such engagement shall be for a longer period than five years. A Managing Director shall not retire from office by rotation during the period of his engagement."

"2. The number of Directors (including any Managing Director) shall not exceed seven nor be less than four, and every Director shall hold at least 100 shares in his own name as the sole holder thereof. The Directors may from time to time appoint any additional Directors or Director, provided the number of Directors shall never exceed seven."

"3. The remuneration of the Directors other than a Managing Director shall be from time to time determined by the members at the ordinary meeting; but any proposal for the alteration of the remuneration of Directors shall be deemed special business, requiring seven days' notice to be given thereof."

"4. The Directors may from time to time sell, lease, exchange, or otherwise dispose of and deal with all or any parts or part of the property of the Company situated in France upon such terms and in such manner as they may think expedient."

The CHAIRMAN stated, in answer to remarks and questions, that in future the report should be sent to the shareholders fourteen days before the meeting was held. It was not proposed by the third resolution to make any alteration in the system under which the Directors were at present remunerated.

A vote of thanks was then passed to the Chairman and Directors.

The CHAIRMAN, in reply, said: In the name of my co-Directors and self I beg to thank you for the kind manner in which the resolution has been proposed and responded to. Already I have referred to the attention given by the Board to the affairs of the Company; but I have great satisfaction in including my friend Mr. Gray in that vote. Upon our shoulders much of the credit due to him has fallen. Accept our thanks and assurance that our attention to your interest will not in the least slacken, and we hope to meet again in twelve months with as satisfactory an account as we have on the present occasion rendered to you.

The proceedings then terminated.

BUSINESS NOTICE.—Messrs. Elliott Brothers inform us that the premises, at 449, Strand, which they have occupied for so many years past, are required for other purposes on the 25th March next, and that their whole business of optical, mathematical, and electrical instrument makers, &c., will be carried on from that date at their manufactory, 101 and 102, St. Martin's-lane, Charing-cross, W.C.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Feb. 17.		Business Done Week Ending Feb. 17. Highest.	Lowest.
Anglo-American	32½,	33½	33⅜	33⅛ x d.
Do. Preferred	55,	56	56¼	55¾ x.d.
Do. Deferred	10,	11	10¾	10½
Brazilian Submarine	10⅞,	11⅛	11 1-16	10⅞
Cuba	10¼,	10¾	10 7-16	10¼ x.d.
Do. Preference	17,	18	17 7-16	— x.d.
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9⅜,	9⅝	9⅝	9⅜
Eastern Telegraph	11¾,	12	11 15-16	11¾
Do. 6 per Cent. Preference	13⅞,	14⅛	14	13⅞
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	12⅞,	13⅛	13 1-16	12⅞
German Union	9½,	10	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 1-16	6⅞
Do. Preference	13⅜,	15¾	13⅝	13 7-16
Great Northern	14½,	15	15¼	14 13-16
Indo-European	33½,	34	34	33½
Reuter's	7,	7½	7¼	—
Submarine	205,	215	212	208½
West India and Panama	⅝,	⅞	¾	—
Do. 1st Preference	8½,	9	8⅞	8¾
Western Brazilian	6¾,	6¾	6¼	—
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	15-16,	1 1-16	—	—
Oriental	3-16,	5-16	—	—
United Telephone	12,	12½	12¼	12 1-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3⅜,	3⅝	3 11-16	3½ x.d.
Do. (fully paid)	5¼,	5¾	5 11-16	4⅞ x.d.
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1⅜,	1⅝	1¾	—
Maxim-Weston	5-16,	7-16	⅜	—

MISCELLANEOUS.

Telegraph Construction	38,	39	38½	37½
India Rubber, Gutta Percha, and Telegraph Works	23½	24½	24½	—

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NOTES.

MERCURY.—It is reported from Odessa that very rich and extensive quicksilver mines have been discovered in the basin of the Donetz.

ERDITE.—An American company is now manufacturing filaments for incandescent lamps of a new material called "erdite," a metalloid.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 19th inst. amounted to £3,241.

A CAT BATTERY.—There was a very funny article in last week's issue of *Illustrated Bits* on the cat as a galvanic element. It was entitled the "Cat Battery."

PRIVATE BILLS IN PARLIAMENT.—A petition was presented last week against the West London Electric Lighting Bill, from the Strand District Board of Works.

OBITUARY.—We regret to hear of the death of Mr. C. W. Hutchinson, B.S.C., Postmaster-General of Madras. Mr. Hutchinson died on the 30th ultimo at the age of 52 years.

TELPHERAGE.—On Monday last Professor W. E. Ayrton delivered a lecture at the Midland Institute, Birmingham, on "Telpherage; or the Automatic Electric Transport of Goods and Passengers."

THE PROFIT ON MICROPHONES —Some one figures out that in ten years the instruments, which cost the Bell Telephone Company $3·42, have each yielded a gross revenue of $178·74.

LECTURE.—On Monday evening Mr. W. J. Lancaster delivered a lecture at the Public Hall in connection with the Leamington Institute, on "Electricity, Past, Present, and Future."

THE SS. "GREAT NORTHERN."—This vessel left England about a month ago for Zanzibar, where she will be stationed as the Eastern and South African Telegraph Company's repairing steamer.

VICTORIA, AUSTRALIA.—A Reuter's telegram dated, Melbourne, February 22nd, announces the appointment of the Hon. F. T. Derham to the office of Postmaster-General in the newly-formed Coalition Ministry.

NEW ZEALAND.—The local press of New Zealand generally strongly supports the action of the Government in reference to the New Zealand cable reduced tariff, and advocates the laying of a second cable rather than a ten years' contract.

THE TELEPHONE IN BELGIUM.—The contract for the establishment and exploitation of a telephone system in the town of Termonde will be let on the 24th of March, and not on the 24th of February, as previously announced.

ROSCOBIE.—A series of popular lectures for young men are being given at the above place. At a meeting which was held last week Mr. Farquhar intimated that he had arranged for an early lecture on electricity by the Rev. W. Oldham.

ELECTRICAL RAILWAYS.—It is computed that there are now in the world about 13 electrical railways; the total mileage of 40·8. This we should say is underestimated. The longest line is that between Geneva and Saint Julien, a distance of about 10 miles.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 19th inst. were £2,560, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

CORRECTION.—By a singular accident, the Essays on "Popular Government" referred to in our leading article last week was described as being the work of Sir Henry Mayne. Of course, the book in question is the one recently published by Sir Henry Maine.

ITALY.—Messrs. Armington and Sims have received an order for a number of additional engines from the Italian Government, to be used for electric lighting purposes in Milan. This order will make twenty engines of this company's manufacture in use in Italy.

TELEGRAPHS.—From recent statistics it would appear that during the past year about 2,500 telegraph offices were opened in different parts of the world. Among these may be mentioned six towns in Bolivia, ten in China, four in Corea, six in Paraguay, and four in Persia, &c.

NEW PUBLICATIONS.—There is about to be published by M. A. Lefevre, of Brussels, a work entitled "Concours International de Traction Mécanique et de Matériel de Tramways," being the report of a special international jury of the Antwerp Exhibition. The price is moderate.

PRIVATE CARRIAGE LIGHTING.—Many private carriages are now lighted in Paris by electricity. The lamps are connected with small accumulators placed under the driver's seat, being removed and charged with electricity from a dynamo during the daytime, for use at night.

THE MINER'S LAMP.—Mr. J. W. Swan has been giving an exposition of his new electric safety mining lamp to the members of the Glasgow Philosophical Society. The paper was substantially the same as that lately read in Newcastle, and its author received a cordial vote of thanks.

SOCIETE BELGE D'ELECTRICIENS.—This society is occupying itself with a discussion on the following subjects:—Fundamental principles of electricity, measures, batteries, dynamos, transformers, storage cells, lamps, electric lighting, distribution of electrical energy, and the telegraph and telephone.

SINGAPORE.—We are informed that a very successful subscription fancy dress ball took place at the Singapore Town Hall early in January. A notable feature in connection with the ball was the employment of the electric light in lighting the Town Hall, the entrance hall being brilliantly illuminated under the direction of Mr. Wells.

OVERHEAD TELEPHONE WIRE IN AMERICA.—Reports from St. John, New Brunswick, state that the wires all over the country continue to suffer severely from the late hard weather and heavy snow. Bad reports come from the Dominion. At St. John, New Brunswick, out of 170 miles of telephone wire in operation, not more than 25 miles were left on the poles.

TELEGRAPH CLERKS.—A largely-attended meeting of the second-class clerks of the Central Telegraph Office was held on Wednesday evening, at the Foresters' Hall, Clerkenwell, to consider their position and prospects. Amongst the resolutions passed was one expressing sympathy with the provincial telegraph clerks on their not receiving payment for Sunday duty.

LAYING SUBMARINE CABLES.—We should like to know how it is, when submarine telegraph cables are laid close in shore, where cross-bearings and sights can be readily obtained, their position cannot be more correctly laid down on the charts. It not unfrequently happens that an error is introduced varying between three-quarters of a mile and five or six miles.

THE TELEGRAPH BATTALION.—A piece of plate has been presented to the Royal Engineers officers' mess, South Camp, Aldershot, by the officers of the Telegraph Battalion, who

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were recently employed on active service on the Nile at Suakim, and in Bechuanaland. The piece is a tazza of Spanish workmanship, and is set with a large number of exquisitely cut cameos.

LONG DISTANCE TELEPHONY.—The Vienna correspondent of the *Standard* reports that the telephone trials between Brünn and Vienna, which commenced on Wednesday, are being continued with completely successful results. The ordinary telegraph wire was used, without interruption of the service, and the words were not only audible, but the speaker's voice could be distinguished.

ABERDEEN.—The Education Committee of Gordon's College have resolved to proceed at once with the lighting of the east wing of Gordon's College by electricity, and to accept the estimates of Messrs. Menzies and M'Whirter for the supply of a dynamo and the necessary leading wires, lamps, and fittings; and arrangements have been made to have the work, as far as possible, executed during the ensuing vacation.

TOWN LIGHTING.—We notice that tenders are invited, and will be received until 1st April, 1886, for lighting the city of Asheville, North Carolina, with electricity or gas. The lighting area is about 1½ mile square, and the population 6,000. Tenders are also asked for by the City Council of the City of Freeport, Illinois, for the lighting of the city with electric lights, for the term of one to five years, from the 1st day of May, 1886.

TELEGRAMS AT THE ROYAL COURTS OF JUSTICE.—In order to expedite the transmission of telegrams to the Royal Courts of Justice, the superintendent, Mr. Hantler, has, with the sanction of the Lord Chancellor, made arrangements with the postal authorities, whereby all telegrams will be wired direct to that building, instead of to the Fleet-street office as hitherto, and will be at once delivered by messengers attached to the telegraph office in the courts.

THE ELECTRIC LIGHT IN AMERICA.—There is, says a contemporary, little ground for surprise at the progress made by the electric light in America when the price paid for gas is considered. A list of the prices per thousand cubic feet shows that the lowest price charged is 4s., namely, at Baltimore, Pittsburg, and Chicago. From this price it ranges up to 16s. at Galveston and San Antonio, Texas. The most usual price is 10s., and an average may be taken at 8s.

THE MECHANICAL TELEPHONE.—A writer in the *Electrical World* comes to the conclusion that enough has been already accomplished and practically demonstrated to place the success of the mechanical telephone beyond cavil, and is of opinion that its rapid adoption by railway corporations and private individuals is indisputable evidence of its growing popularity. We, on the other hand, are of the opinion that the mechanical telephone has a more limited sphere of operation than is indicated by our contemporary.

FOLKESTONE EXHIBITION.—The contract for the lighting of the Folkestone Exhibition has been given to the Electrical Power Storage Company. There will be 1,250 incandescent lamps for the lighting of the picture galleries, which will be supplied from two Crompton shunt-wound dynamos and two sets of E.P.S. batteries. The central nave, refreshment room, gardens, &c., will be lit by 36 Crompton arc lamps of 3,000 candle-power, the necessary power being obtained from two 30 horse-power Marshall engines.

A DISASTROUS EXPERIMENT.—An American exchange says that Harry Worman, a bright boy of Fostoria, Ohio, according to a report from that place, showed so much interest in electrical experiments that he became a privileged character at the electric light works, no other outsider being permitted near the dynamos. The other day he wanted to receive a "good shock," and so got a pail of water and, touching the positive pole of a dynamo with a rod in one hand, put the other hand in the water, and fell back dead.

THE INDIAN NATIONAL TELEGRAPHIC UNION.—It is announced that the Indian National Telegraphic Union is now in full working order. Sufficient funds have been collected; local committees have been organised at the principal stations throughout India, which will keep the committee here informed about current events within their respective limits; and telegrams are now being regularly despatched, giving the English public information about important events in India, and about the Indian view regarding such events.

THE SLAMMOPHONE.—A Pittsburg paper says that an instrument, called by its maker the "slammophone" (probably from the Greek *slammus*, to bang the door, and *phonos*, to make a noise !), is attached to the door of the Clarke studio, Oakland. The slammophone, which is something like an Æolian harp, is fastened against the door in such a way that a series of pendent hammers strike the strings when the door is opened or closed. The coming or departing guest is therefore greeted by a concourse of sweet sounds of his own making, and, until informed, cannot for the life of him tell where the weird music comes from.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—From the report of this company it appears that the accounts for the year show a net profit of £82,740. 15s. 8d., to which must be added £72,166. 8s. 7d. brought forward, making a total of £154,907. 4s. 3d. From this amount is deducted the interim dividend of 5 per cent., leaving £132,497 4s. 3d. to be dealt with, out of which the directors propose to distribute a dividend of £1. 16s. per share, making, with the amount already paid, a total for the year of £2. 8s. per share, or 20 per cent., free of income-tax, leaving £65,267 4s. 3d. to be carried forward.

ELECTRIC LIGHT IN FIFE.—On Monday night a number of spectators were attracted to the harbour to witness the first exhibition of the electric light which had been seen in the locality. A new Norwegian steamer, the "Faerder," arrived from Christiansand on Sunday evening with a few passengers and a cargo for Burntisland and Grangemouth. In order to complete the discharge of the Burntisland portion on Monday night, the electric light, with which the vessel is furnished, was employed. Two lamps were suspended from the masts fore and aft, the dynamo being worked by an engine of seven horse-power. The illumination proved of great convenience.

"PRIMERS OF ELECTRICITY."—For the information of many of our foreign subscribers who have asked the question, we may say that the "Primers of Electricity," while being of an elementary character, are intended for the use of students of electricity rather than the general public. Besides a variety of useful and clearly written explanations of almost every kind of electrical apparatus and machinery, the little work contains a few eminently practical papers on submarine cable engineering. We would especially commend these latter to the notice of the *employés* of cable companies. They will find them invaluable in conjunction with a text book such as Kemp's.

THE DELIVERY OF TELEGRAMS.—In the House of Commons on Monday night Mr. Henry Fowler, in reply to Mr. A. B. Forwood, said it was the opinion of the Post Office that an address which was sufficient for a letter was not sufficient for a telegram. A letter bearing an efficient address in all proba-

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bility fell into the hands of a postman who had letters to deliver to the same person almost every day; whereas a telegram was delivered by a messenger who might never have heard before of the person to whom it was addressed. What the department required in the case of a telegram was that the address should be sufficient to enable the messenger to find the person without delay.

ELECTRICALLY OPERATED FLUSH TANK.—The *Sanitary Engineer* says that Mr. D. W. Hyde, of Boston, Mass., has invented an interesting novelty in flushing apparatus. He has contrived by means of an electric current, such as is used ordinarily on electric call bells, to relieve the weighted end of a lever and thereby to lift a valve in a tank, which is closed automatically and the lever placed in position to again be dropped on touching a button located anywhere. If desired, it can be arranged to trip the lever at intervals, making a tank with an automatic intermittent flush, and a switch can be arranged so that at any time it can be changed to be operated, at the will of the user, by the push button.

THE LIGHTING AT ROCHE-SAN-FORON (HAUTE SAVOIL).—In this installation the water supply is taken advantage of. A fall of 17 metres is utilised to drive a Girard turbine of 45 horse-power, which in turn actuates a Thury H_1 dynamo, giving 150 amperes, with a mean difference of potential at the terminals of 110 volts, at a velocity of 600 revolutions per minute. An uncovered copper cable 4 kilometres long and of a mean section of 240 mm^2 is used in the installation, but the supply leads are on the Berthoud-Borel system. The lamps are the Edison of 10, 16, and 32 candle-power. When in full work the distribution amounts to about 22 electrical horse-power, or, roughly speaking, to 250 lamps of 16 candle-power.

ELECTRICAL FIRE ALARMS.—On the 23rd inst. Mr. W. L. Carpenter made an interesting contribution to the weekly series of Penny Science Lectures in progress at the Victoria Hall and Coffee Tavern. The subject was that of American electrical fire alarms. Remarking at the outset of his lecture that on the outbreak of a fire the first five minutes were worth the next five hours in respect of the efforts made to extinguish it, Mr. Carpenter pointed out that on the American continent this fact had been far more thoroughly appreciated than in the old world. In London and in Glasgow public fire alarms were only used in a few isolated cases, whereas in the great cities of America they formed part of a large and important system.

NOT ALL ON ONE SIDE.—The gas journals make such capital out of an occasional accident to a dynamo that we may be excused for departing for once from our usual rule of observing silence on the subject of the numerous disadvantages of gas lighting. The following paragraph will show that the complaints which have been urged against the electric light are equally applicable to the more malodorous luminant:—"The town of Deal was suddenly plunged into darkness on Wednesday through an accident at the gas works. The incident caused the greatest confusion, and being a dark night the main thoroughfares for some considerable time presented a singular spectacle, the tradesmen, in the general confusion, hastening to close their premises."

THE ELECTRIC LIGHT IN PARIS.—From further advices we learn that the installation in the Artillery workshops at Saint-Thomas-d'Aquin, will consist of 2 Gramme lamps of 300 candle-power, and 82 incandescents, of which 2 are of 25 candle-power, and the remainder of 10 candle-power. These will light the workshops only. In addition each workman will have a 10 candle-power lamp for his own use. The current is supplied by 2 Gramme dynamos giving 50 amperes with a difference of potential of 70 volts. The installation has been put down by Messrs. Buchin, Tricoche and Co. The Rochechouart public baths are now electrically lighted. This installation comprises 12 Edison incandescents of 20 candle-power, and 20 Street and Macquaire arc lamps.

THE ELECTRIC LIGHT IN AUSTRIA.—A contemporary reports that an installation of 250 lamps of 16 candle-power has just been completed by a Vienna firm at the hunting seat of the Emperor of Austria in the Zoological Gardens at Lainz, including 120 lamps of 25 candles each for lighting the road about 2¼ miles in length. There are four dynamos driven by a twin engine working normally up to 35 horse-power. Two dynamos light the buildings, to which place the wires are well protected and laid underground; they are made up into lead cables enclosed in tubes of prepared wood, or into cables embedded in the best asphalte and contained in solid wooden boxes. The lamps are placed on the two sides of the road, and are joined in series; each side being lighted by a separate dynamo. These lamps are fixed on posts and the connections are made with an uncovered copper wire from post to post.

TELEPHONIC LITIGATION.—We announced recently that writs had been served by the United Telephone Company upon Mr. Wilfrid Fleming, of Liverpool, for alleged infringement of Bell's and Edison's telephone patents, and we ventured to remark that, as the only instruments which Mr. Fleming had been selling and erecting were the valve transmitter (Prof. Silvanus Thompson's patent) and the English mechanic receiver we doubted whether any serious attack was intended, especially as the new telephone company was known to be prepared to guarantee Mr. Fleming against the attack of the United Company. Our forecast is likely to be justified by the event, as we have the very best means of knowing that affidavits have been filed by the manager and by the solicitors of the United Telephone Company, the effect of which is to withdraw from the attack so far as the new telephone company's instruments are concerned.

CHESS BY TELEPHONE.—Two games of chess were played a few days ago between members of the Manchester and Liverpool Chess Clubs, assembled in their respective club-rooms, which are forty miles apart. Communications were carried on by telephone. The Lancashire and Cheshire Telephone Company had made special arrangements by which the players could converse with as much certainty of being understood as if they were seated in the same room on opposite sides of the chessboard. Non-players had also opportunities of hearing the verbal messages which passed to and fro, and some found entertainment in the strains of the Theatre Royal orchestra, which trespassed on the same wire and could be heard in a subdued form. Much satisfaction was expressed with the working of the telephone, all the moves—over thirty on each side in one game and about forty in the other—being transmitted without a single mistake.

INDIAN TELEGRAPH DEPARTMENT.—In the House of Commons on Monday night Mr. Conybeare asked the Under Secretary for India whether it was the fact that the complaints of the officers of the Telegraph Department in the Government of India in respect of absence of promotion had been long admitted by the Government of India to be well-founded; whether any and what steps had been or were about to be taken to remedy their grievances; and whether he would communicate with the Government of India with a view of laying before Parliament at an early date all the papers relating to the subject. Sir U. Kay-Shuttleworth said the fact that there are grounds for complaint had been admitted,

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and was the subject of correspondence with the Government of India, with the hope of increasing the efficiency of the department and remedying all just grievances. As soon as possible information would be given to Parliament.

BIRMINGHAM.—A contemporary says:—"The meeting of the British Association, fixed to take place in Birmingham on 1st September, will be the fourth that has been held in that town, the dates of previous meetings there being 1838, 1849, and 1865. Following the precedent set on these occasions, it has been arranged to hold, concurrently with the meeting, an Industrial Exhibition of the local manufactures. This Exhibition, which will be open from 26th August to 1st October, however, is to be on a scale of completeness not previously attempted. The manufactures of Birmingham and the surrounding districts, within a circuit of 15 miles, will be fully represented, and in most cases processes will be shown, or at least clearly indicated. The trades represented will be engineering, hardware, heating and lighting, arms and ammunition, jewellery, glass and pottery, stationery, leather, furniture and decoration, with a section devoted to scientific and musical instruments.

THE TELEMICROPHONE.—Under this title M. Mercadier has designed an instrument which combines the properties of the microphone with those of the telephone. The following is a method of construction recently described by the inventor. To the diaphragm of an Arsonval telephone are fixed, after being enclosed in a cylinder of thin iron, the carbons of an Arsonval and Bert microphone. These carbons are in the interior of the apparatus, and the pressure they exercise upon their support is regulated by a small auxiliary magnet. The electrical connections are the same as those in an ordinary microphone. When the diaphragm receives a sound wave it vibrates and produces two simultaneous effects, *i.e.*, a microphonic effect in the primary circuit of the coil, by reason of the movements of the carbons fixed to the diaphragm, and a telephonic effect by reason of the movements of the diaphragm in the field of the magnet. The instrument is intended to be used as both a transmitter and a receiver.

FIRE AT A TELEGRAPH WORKS.—On Saturday morning, at half-past ten o'clock, the fire brigades at Woolwich and Greenwich were called to the very extensive telegraph apparatus works of Messrs. Siemens and Co., in Harrington-road, Woolwich. The firemen found that an occurrence of a serious and alarming character had happened in a one-floor building used for the preparation of gutta percha for telegraph wires. It would appear that, with a tremendous report, a still exploded with great violence, and the melted substance spread all over the building, and soon caught fire. Without delay two of the private hydrants fitted to the place were got to work, but the burning matter flowed into the yard and set fire to the stock. For a time the fire burned with great strength, and appeared of a very threatening character, but the firemen eventually succeeded in subduing the outbreak. Serious damage, however, was caused by the fire and explosion to the building and its contents, as well as to the contents in the yard.

ELECTRICITY AND MEDICINE.—At a recent meeting of the French Academy of Medicine, M. Brondel read a paper on the introduction of certain medicines into the system by means of electricity. If the electric current is made to pass through a solution of a salt, the salt is decomposed, the metallic base passing to the negative pole, and the acid, or metalloid, to the positive pole. The iodides are easily decomposed by electricity. In order to introduce iodine into the system, a rubber plate, moistened with a solution of iodide of potassium, is placed upon the surface of the body. Over this plate the negative pole of a battery is applied, while the positive pole is placed upon a part of the body toward which it is desired that the iodine should travel. The iodine separates from the potassium, which remains at the negative pole, and passes with great rapidity through the tissues towards the positive pole. This may be demonstrated by testing with a starched paper, which becomes blue. A great number of substances can thus be made to traverse the tissues, and the applications of this discovery are numerous and important.

LIGHTING OF LONDON BANKS.—The Electrical Power Storage Company have just completed an installation at the Bank of New South Wales, Old Broad-street, E.C., consisting of about forty lamps of Woodhouse and Rawson manufacture, supplied by a Crompton dynamo, and a set of thirty-one of the E.P.S. cells, type 15 L., in glass boxes. The engine is a 3½ h.-p. Otto, and the special arrangements made enable the machinery to be run at any time in the day without the slightest noise being heard either in the Bank itself or in the neighbouring premises. It will be remembered that this company have an installation at the Bank of England, which has worked throughout most successfully, and we are informed that the same set of cells has been in use since the installation started, more than two years ago, without being renewed in any way. The company are also engaged in fitting up the new premises of the English Bank of Rio Janeiro, in Moorgate-street, on the same system, and there is no doubt that other banks will adopt the light now that it has been shown that the gas engine need not cause inconvenience if the proper precautions are adopted.

TESTS OF INCANDESCENT LAMPS.—From an account of some further experiments carried out by Mr. Peukert at the Upper Technical School, Hanover, with a number of incandescent lamps by various makers we extract the following:—The Siemens and Halske 98-volt incandescent lamps took a current of 0·554 ampere. The mean temperature observed was equivalent to a radiation of about 35·7 calories per hour. The candle-power of the lamp in air was 8·8. The Edison 93·6-volt lamps required 0·963 ampere. The mean temperature was 55·26 calories per hour and the candle-power 16·9 in air. The Swan 76-volt lamps required 2·55 amperes. The temperature was 124·19 calories per hour and the candle-power 30·0 in air. Expressing in calories the work of the current we get the following particulars:—With the Siemens and Halske lamps the total work of the current per hour appears as 46·98, of which 11·28 calories only were converted into light. With the Edison, the total work being 78·01, the energy appearing as light was 22·75. With the Swan lamps, of a total of 167·86 calories 43·67 were absorbed for light.

THE NORTHERN DISTRICT TELEPHONE COMPANY.—This company, we are told, are very busy just now with their various trunk lines, particularly that between Hartlepool and Stockton, while all the preparations for completing the trunk between Sunderland and Hartlepool are now in order, and the work will be proceeded with at once. In this district winter is again having an innings, and during the past week there has been every conceivable kind of weather. Snow has been falling during the last day or two; but though it is in its most destructive condition as far as overhead wires are concerned, namely, soft, and what schoolboys call "binding," none of the wires have suffered. The pantomime, laid on from the Theatre Royal, Newcastle, has been a great source of amusement to the subscribers at Sunderland lately, but the quaintest effect was produced a short time ago at an evening party, where the accompaniment of a song was played, while a gentleman at the company's exchange about a mile off sang the song. Each of the performers had a telephone held to his ear, so the musical

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circle was complete, while the audience heard the song through the telephone with one ear, and the accompaniment in the room with the other.

Promotion of Scientific Knowledge. — Many of our readers will be aware that the King of the Belgians founded some time ago an annual prize of 25,000fr. (£1,000) for the promotion of scientific knowledge. This sum, which represents the third international prize competition, will be granted in the year 1889 for the best work on the progress of electricity as a motive power and for the purposes of illumination, on the various forms in which electricity is used or might be made use of, and on the economical advantages which the application of electricity appears destined to afford. Foreigners who desire to participate in this competition must send their essay printed or in manuscript before January 1, 1889, to the Minister for Agriculture, Industry, and Public Works in Brussels. A new edition of an already printed work will only be admitted to the competition when the same has undergone considerable modifications and been greatly enlarged, and provided the same shall have been issued, like the other works submitted, within the years 1885, 1886, 1887, or 1888. The essays may be written in any one of the following languages:—German, French, Flemish, English, Italian, and Spanish. The King of the Belgians will elect a jury as judges for awarding the prizes, composed of seven members—viz., three Belgians and four foreigners.

The Electrolytic Cartridge.—We learn from a description of these cartridges given by a contemporary that the cartridge consists essentially of a glass tube of a diameter to fit easily into the borehole, which should be small. The tube is very strong, the thickness of its walls being about equal to the diameter of the bore. Two wires are fused into this tube, which is hermetically closed after being nearly filled with water rendered conductive with a little acid or some metallic salt. When this cartridge has been inserted into the borehole, and the latter tamped or stemmed in the usual way, its projecting wires are connected with cables serving as "leads" from a source of electricity. All being ready, the current is put on, and the current from the generator passes between the ends of the wires within the glass tube and decomposes the water. The explosive mixture continues to accumulate as the decomposing action of the current goes on. It is to withstand the increasing pressure of the liberated cases that the thick glass is required. So long as the ends of the wires are covered by the liquid, no spark can be produced to ignite the gaseous mixture; but when these—or one of them—are laid bare by the conversion of the water into gas, the current has to pass through the latter, which is then fired. The resulting explosion is extremely violent—more violent than that of nitroglycerine even.

The Lighting of the City.—In his annual report to the Commissioners of Sewers Colonel Haywood says:—Upon the whole it appears desirable for the Commission to offer very liberal terms indeed to those willing to embark in the enterprise of supplying a fairly-sized district of the City with electricity rather than to undertake the work themselves. The risk of profit to the enterprise would be considerable, even if the promoters be paid most liberally for the supply they give; but whatever the cost may be, it would be a cheaper and a better way of obtaining a supply of electricity, either for the city of London or any part of the metropolis, rather than for local authorities to undertake it in the present condition of electrical science. Unfortunately, at the present time there is a complete stagnation in electrical enterprise upon a sufficiently large scale for the supply to a town or large district. This I believe to be solely attributable to the operation of the Electric Lighting Act, under which those embarking in such undertakings are fettered in many ways, and may, after a large expenditure and years of trouble, be deprived of the fruits of their labour with most inadequate compensation, just when success might begin to reward them. Nothing short of the repeal of that Act, or a fundamental alteration in most of its provisions, will bring capital into electrical undertakings again; and the Commission would, I believe, most usefully use its power and position in obtaining an alteration or repeal of the Act.

The Telegraph and the late Riots.—The report of the Committee of Inquiry into the matter of the late West End riots contains the following:—"We have also to call attention to the very inadequate arrangements made for telegraphic communication between the police in the streets and the Commissioner's head-quarters at Scotland-yard. We find that no constable was aware that from the War Office it was possible to have sent a telephonic message to Scotland-yard at any time. Had the police-constable, who is always on duty in front of the War Office, been aware that he could send such a message, he could easily, when the mob had assembled in front of the Carlton Club, have informed Scotland-yard of the fact, where arrangements could have been made for heading the mob. The same want of system is evident with regard to the use of the postal telegraph. The constables on duty at the bottom of St. James's-street, where there is a postal telegraph office, should, in our opinion, have had the power of entering the office and giving the order to the telegraphist on duty to clear the line at once to Scotland-yard. Had this been done, a message could also have been received by the Commissioners there, which would have enabled them to have taken prompt measures. The same applies to all other telegraph offices along the route taken by the mob. We also wish to call attention to the fact, that at Scotland-yard, and the police stations generally, there seems to be no telegraphic signal by which the urgency of any particular message can be specially indicated."

The Electric Light for War Ships.—A trial has just been made at Portsmouth of an installation of the electric light, which has been fitted on board the "Impérieuse" by Messrs. Siemens Brothers and Company, who are also about to provide similar installations on board the "Warspite," "Edinburgh," "Collingwood," and "Rodney." The lights on board the "Impérieuse" comprise 375 incandescent lamps of 20 candle-power, which are disposed so as to illuminate all parts of the ship, including the engine rooms, stokeholes, and magazines; and also a couple of search arc lights, placed at the bows and at the stern, and which are each equal to the power of 25,000 candles. The currents are generated by three Siemens dynamos, on the combined and self-regulating principle, each of which is driven by one of Willans's compound two cylinder engines, which is fixed to the same bed-plate as the machine which it drives. The number of revolutions per minute is 400. The machines are interchangeable, and can be connected or thrown out of action by a simple switch arrangement. One of the machines supplies the search lights, and another is equal to maintaining 320 of the incandescent lamps aglow, which is considered as many as will be necessary as a rule to be alight at the same time. When the whole of the incandescent lamps are required to be lighted at the same time two dynamos will be demanded for the several leads, otherwise one will be kept as a reserve against accidents. The arrangements have been superintended on behalf of the company by Mr. Collings, and the preliminary trial during the day and after dark proved very satisfactory.

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TELPHERAGE.*

BY PROFESSOR JOHN PERRY, F.R.S.

(Continued from page 289.)

It has been suggested by our friend, Mr. Gordon Wigan, that instead of the wire we might have a copper strip attached all along the train to the more or less flexible draw bars, and that the draw bars might be brought much nearer to the rod than they are in this model, and that the contact of such a strip of copper with fixed brushes, or pulleys, might easily be arranged for.

In our system there is no necessity for insulating any part of the steel rod on which the trains run; but you will see presently that such insulation has given no trouble whatever; whereas the hanging wire might by its oscillation become entangled in some part of the train, while in the copper strip and drawbar, or *back-bone* plan as we call it, which Mr. Wigan has suggested, an expensive brush or pulley must be placed at every post. Although, therefore, both the plan suggested by Mr. Wigan and our own plan which you see carried out in this model, obviate the disadvantage of the reversal of the current when the train is passing the posts, neither of them is as simple as that of Prof. Jenkin.

Here is another model, worked on the Cross-Over System, in which the ends of the Telpher Line are stiff and the inter-

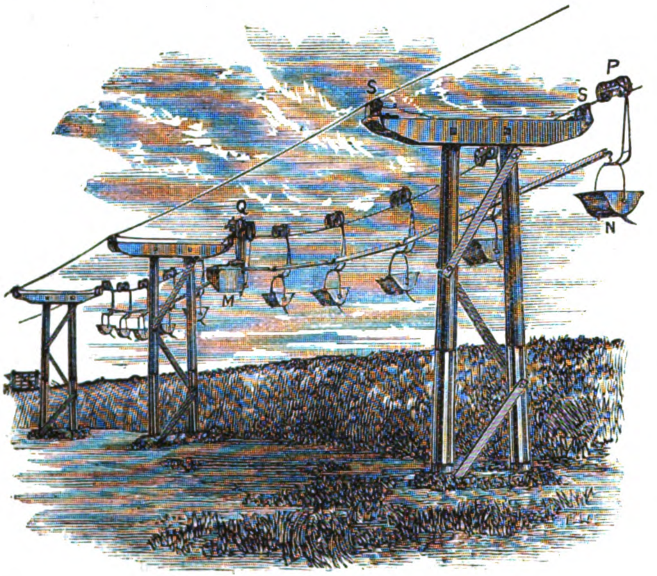

Fig. 9.

mediate parts flexible. Imagine these rods as being each 66ft. long and about 18ft. above the ground, supported on rough timber posts, here going across a river, there over houses, rising and falling and curving about as the ground and obstructions require it to do; imagine also these flexible rods as being 8ft. apart everywhere, and their aggregate length a number of miles, then with these buckets weighing nearly 400lb. each, you have a real telpher line. [Model of Cross-Over Parallel Telpher Line shown working.]

To assist your imagination I will now throw on the screen views taken from three photographs of the Glynde line. The first (Fig. 9) gives a view of the train just before it crosses the river, and you see the river embankment behind the posts. Observe the rough construction of the posts, the straightness of the steel rods before and behind the train, and their sag or dip underneath the train. M is the locomotive which pushes five skeps and pulls five others. It was up this steep incline that we started running on our opening day, when so many engineering authorities were present, and it is this part of the line which is shown crowded with spectators in the engraving of the *Graphic* newspaper.

In this second view (Fig. 10) we see the river itself, there being a descent on both sides of the portion now in view. The line rises here to give the headway necessary over a small navigable river, and the temporary bridge erected by us crosses the river in front of the engine house A.

In the third view (Fig. 11) the nearest post is the one in front of the engine house, and we look towards the clay field from which the skeps are coming loaded.

In this fourth view (Fig. 12) we have the stiff curve at the railway, where the skeps discharge their load of clay into the

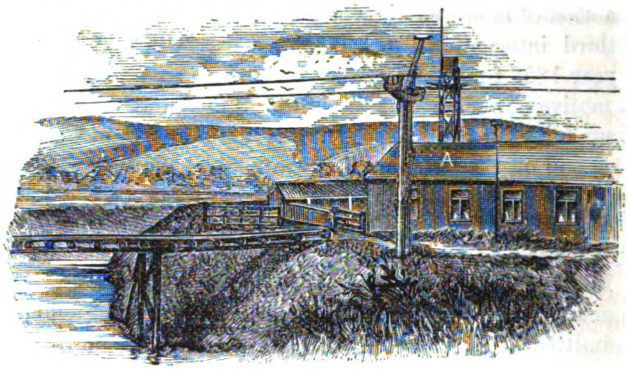

Fig. 10.

railway waggon (see Fig. 17). Some of the supports here are different from the others, being older ones used in some of our earlier experiments. The motion of the train over this curve has a beautiful appearance from the railway bridge.

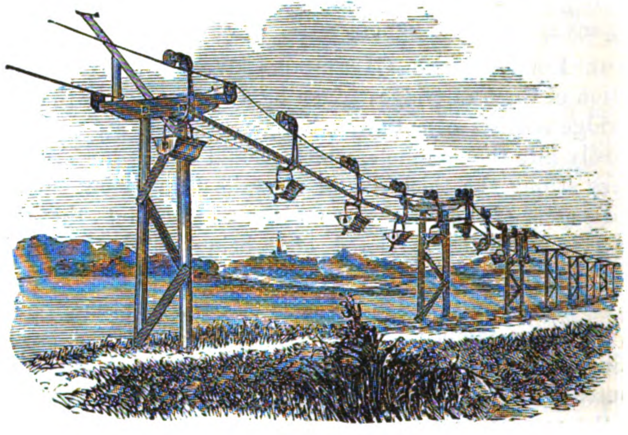

Fig. 11.

In this map (Fig. 13) A is the clay field, where there is a stiff end; B is at the railway siding; C, C shows the flexible part of the line, there being only one stiff part at the curve D; E is the engine house.

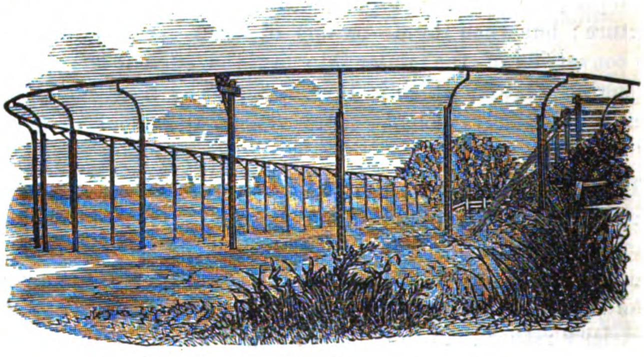

Fig. 12.

Returning to the model. When I send a current you see these two trains proceeding steadily round and round, each of them propelled by its little locomotive placed in the centre of each train. Observe that we have a block system. One of the trains moves more slowly than the other, which is continually trying to run into the first, and is always being pulled up when it comes within too short a distance of the front one. [Absolute Block shown in action.]

* Lecture delivered at the London Institution, 28th January.

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In the construction of an ordinary railway one of the greatest expenses consists in obtaining permission from Parliament to buy land compulsorily; another is the price of the land itself; further, the railway when it does not follow, and it very seldom does, the surface of the ground, must have great embankments made for it, and deep cuttings and tunnels, not to mention that the cost of a railway bridge over a river or a ravine would sometimes swallow up all the possible profits on a short line of ordinary railway. Now, for a Telpher Line the land need not be bought, only way-leave being required; neither embankments nor cuttings are necessary, the uses to which the fields have been put need not be changed, and the crossing of a river or ravine is as easy and inexpensive as carrying the line over ordinary ground.

I remember once lying on the heather, resting in a certain dale in Derbyshire. It was soon after the Telpherage Company was started, and I saw a very long heavy goods train coming out from a tunnel in the mountain on one side of the dale, moving slowly over a railway embankment, which was about a mile long, and passing into the mountain on the other side of the dale.

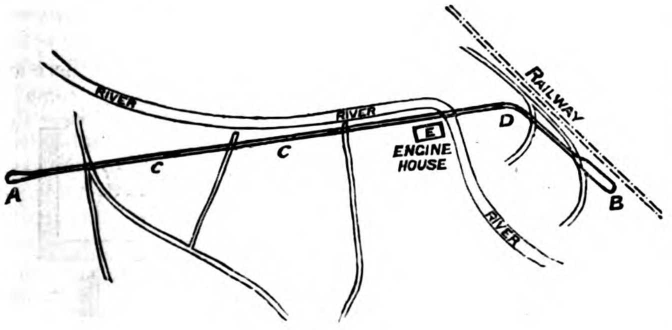

Fig. 13.

When I considered that each of the waggons moving before me might contain 15 to 25 tons of material, and the great number of waggons in a train, and contrasted it with what I knew that a single telpher train was likely to be able to carry, I was for some time very sad in thinking on the prospects of telpherage. But after I had rested there a whole hour, and found that that one goods train was not followed by any others, that for the conveyance of about one train in two hours that costly railway had been built, which was fitted to carry 100 times as much, I felt that perhaps a very cheap line, every part of which was constantly in use by a continuous stream of material passing over it, might really have been very much more economical than the railway I was looking at.

When we consider that electricity furnishes the means of conveying to this little locomotive from a great distance the power required to drive it, that it needs no coals and carries no water, that it need not be much heavier than any one of the ten carriages which it propels, and when we also consider that although each of the numerous trains running on such a line receives its power from the same source, which may be a dynamo machine driven by a steam engine, or driven by a water-wheel or a water-fall, which is several miles away from any part of the line, yet these trains do not interfere with one another excepting when there is danger of a collision, and the interference is then of a very decided character, it will be seen that the idea was one which was certain to be regarded when fully developed as likely to be of tremendous importance in the history of civilisation. As the idea gradually developed we saw that telpherage had no chance of competing with ordinary railways; but we also saw that it was not possible by any ordinary railway system to compete with horses and carts, when the quantity of stuff to be carried was comparatively small, because twenty little steam locomotives, each of one horse-power, would be decidedly uneconomical, even if they could be worked without separate drivers, whereas with telpherage it was quite feasible to have a single train representing the load drawn by a strong horse, and each of our little locomotives might be driven with a wonderful amount of economy. It was known to us, as to other electrical engineers, exactly what was the waste in conveying electric power, and it was seen that our rod might be very light, and therefore cheap, and the whole permanent way cheap if the loads could be subdivided into units of from 2 to 3 cwts. each, so that a weight of 30 cwts. could be spread over a considerable length of line. We saw also that it was possible to develop the system in another direction, and by using stiff girders to carry heavier loads as quickly as we pleased.

When the experiments at Weston and elsewhere were concluded, we proceeded to erect a Telpher Line to take clay a distance of nearly one mile to the Glynde Railway Station, for the Sussex Portland Cement Company (Limited). The designs were made under Prof. Jenkin's superintendence by the staff of the company, but unfortunately in June last the inventor of the Cross-Over System died; and I, whose only claim to credit in this system of Telpherage may be said to consist in having been made by Prof. Jenkin one of his two partners in the enterprise, had the great advantage of being asked by the directors of the company to succeed him as the engineer of the line. Although I had at once to take charge of such design work as had still to be completed by the staff of the company, it was not until the end of July that I was able to settle down at Glynde to superintend the erection of the line. I have been very ably assisted by Mr. Brewtnall, Mr. Crackanthorp, and Mr. Anderson; but the erection of a first working line of such a character as this tried to the utmost my patience and ingenuity. I did certainly introduce modifications into the scheme, but my great desire was to follow as closely as possible the plans of Prof. Jenkin, and although I must confess that I should have preferred to see the development of an Ayrton and Perry system of telpherage, I was all the more intent to construct the Glynde line exactly as I thought the designer himself would have constructed it. I had sometimes difficulty to find the point of view from which he would have looked at some of the problems before me; but I think that his plans were as little changed as they would have been had he lived to carry them out.

If you look at this model and at this map (Fig. 13) you will have no difficulty in understanding how the Glynde line is worked. The steel rod, $\frac{3}{4}$in. in diameter and 66ft. long, has its ends turned sound, and fastened with nuts to these cast-iron saddles (S, Fig. 9) and shown in detail in Fig. 14. Every

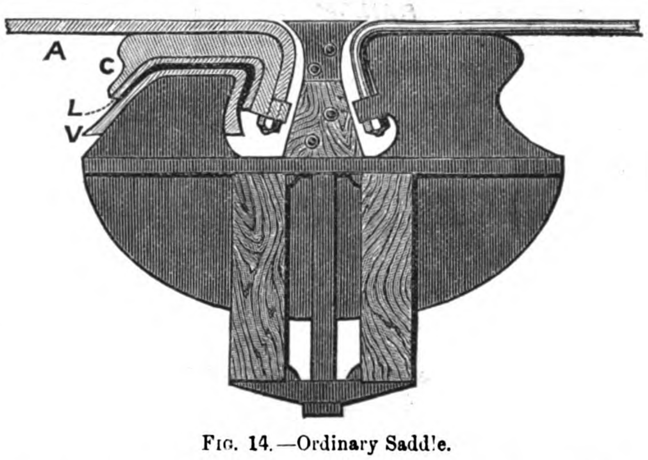

Fig. 14.—Ordinary Saddle.

alternate rod is insulated, and the rod A passes not over the cast-iron saddle itself, but over a cast-steel cap C, which is insulated from the saddle S by an insulator of vulcanite V, and in order that the tension in the rods may be very considerable without fear of the vulcanite cracking or getting broken, melted lead is run in between the vulcanite and the steel and between the cast-iron and the vulcanite, so that the force acting on the vulcanite acts over a wide area of soft lead L. The lead, which was, I believe, suggested by Mr. Charles Wood as preferable to Portland cement, has worked admirably; and since the line was erected we have not yet found that there has been any breakdown in insulation anywhere. The shape of the buckets used you

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will gather partly from the model and partly from the diagram of the real bucket, a side view of which is shown in Fig. 15, and an end view in Fig. 16. At the railway siding the buckets pass over the middle of the railway waggons, as shown in Fig. 17, and the buckets are, one by one, *automatically* tipped and their load of clay discharged into the railway

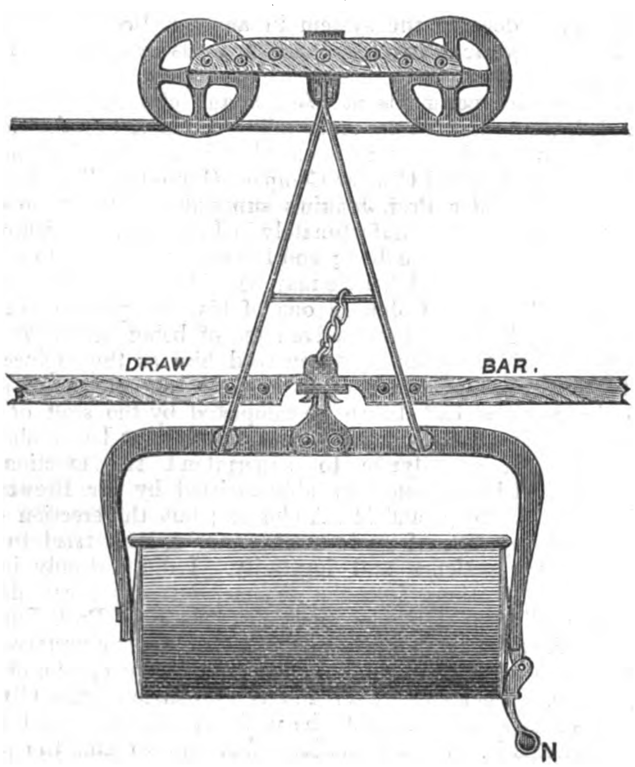

Fig. 15.—Ordinary Bucket (side view).

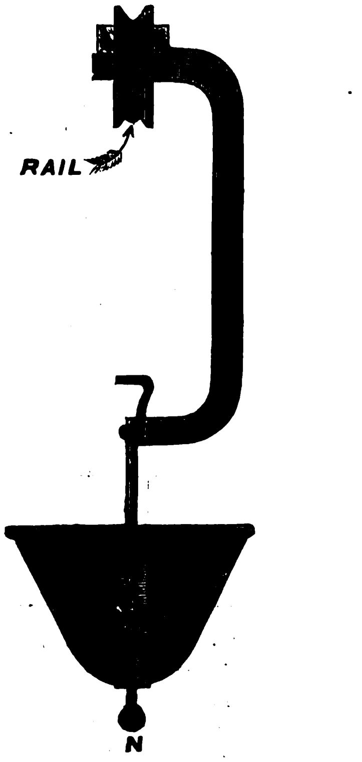

Fig. 16.—Ordinary Bucket (end view).

waggon by the handle N (Figs. 9, 15, and 16), attached to each bucket striking against a buffer, which is made to project from a post at the railway waggon into which the clay is to be emptied.

The old form of skeps experimented with at Weston was copied from those which are used in wire-rope tramways; but it was found that when the pull on the draw bar was suddenly altered these old skeps had a tendency to rear up, and there was a danger of their falling off the line. In the drawing before you of the skep and attachment (Fig. 15), used at Glynde, you will notice that the draw bars are so placed as to produce no tendency to rear when the skeps are suddenly started or stopped, and I believe that in no single instance during three or four months' work has such an accident occurred. You will see that we can hang any load from the hanger, such as a bag, or parcels, or logs of wood by bands instead of the bucket, and in the model we have illustrated this by re-

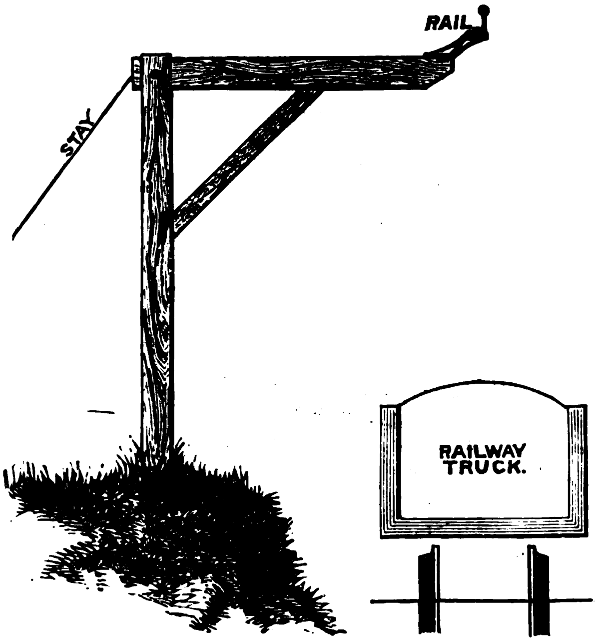

Fig 17.

placing some of the buckets with miniature logs of wood, sacks of shot, &c.

(To be continued.)

LITERATURE.

Dynamo-Electric Machinery. By Prof. Silvanus P. Thompson. [E. and F. N. Spon.]

This is a second and enlarged edition of the book published by the author in the autumn of 1884. Since that time the science and practice of dynamo-electric machinery has advanced with rapid strides, and to keep pace with this development Prof. Thompson has considerably increased the volume of his book, adding over 100 pages letterpress, and nearly the same number of illustrations to the original edition. The general arrangement of the work has, however, not been altered, and as we have already reviewed these in a former number, we shall confine our remarks to that which is new in the present edition.

In Chapter VII., which deals with the types of machines having closed coil armatures, descriptions have been added of the new Gramme armature for large current, of the vertical pattern (1881) Gramme dynamo with salient poles as distinguished from the original horizontal type with consequent poles, of a portable 4-pole Gramme dynamo (type of 1885), of the Breguet type of Gramme machine which, in external appearance, closely resembles Crompton's latest design of Gramme's vertical heavy current machine (type of 1884), of Hochhausen's dynamo, of Kapp's slow-speed dynamo, of the Phœnix dynamo, of M'Tighe's dynamo, of the "Manchester" dynamo, and of the new Siemens vertical dynamo (type of 1885), which also resembles Crompton's design very closely. When criticising the latter the author expresses astonishment that the pole pieces are made considerably thinner than the cores of the magnet, a feature which is in direct opposition to his recommendation on p. 110, where he says:—"If pole pieces are

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used they should be massive and of the softest iron, for reasons similar to those urged above." Now a general rule like that here quoted is apt to be misleading. In some machines, as for instance in the "Manchester" dynamo, massive pole pieces are an unavoidable feature of the general design, and, as such, a necessity; but in some other types no excess of mass is required, and, if applied, may do more harm than good by facilitating an external leak of lines of force. The functions of a pole piece are two—first, to conduct the lines from the magnet core, where they originate, to the surface of the armature, where they do their work; secondly, to reduce the magnetic resistance of the air-space, which object is attained by expanding the pole piece as far as is possible without producing a serious leak of lines. The cross-sectional area of the pole piece at any point is therefore governed by the number of lines which pass at that point, and it is evident that if the field magnets are of the double horseshoe pattern, as in the Siemens or Crompton machines, the centre of the pole piece has not to carry any lines, and might therefore be made as thin as is compatible with mechanical strength. In single horseshoe magnets the area of the pole piece at the centre—that is on a line at right angles to the diameter of commutation—need only be half the area of the magnet core, because half the total number of lines only have to pass that point. In Chapter VIII. dynamos with open coil armatures are described at great length, and the new "Brush" armature core has been added to the original excellent description of the "Brush" dynamo. The Thomson-Houston dynamo is also very fully treated, and the changes of current through the three armature coils during one revolution are very clearly explained. It would, however, have been well if the author had gone a little beyond a mere description, and had shown what part self-induction plays in this machine, especially during the time the brushes are shifted for the purpose of regulating the current. The student would certainly desire to know how it is that an armature producing an electromotive force of several thousand volts is not burned up by a process of regulation which necessitates a periodic short-circuiting of the coils when in a strong part of the field. Chapter XI. is entirely new, and a very welcome addition. It treats of dynamos for electro-plating and electro-metallurgy. As yet there are only very few manufacturers who make machines specially for that purpose, and general information of the requirements of this class of work is obtainable only with great difficulty. The reader will find in Prof. Thompson's book most of the data which are necessary to guide him in the choice or in the design of a dynamo for electro-deposition. Those relating to copper are so generally useful that we make no apology for reproducing them here:—

Current	1	ampere	deposits	·000326	grams	per second
„	1	„	„	·01957	„	per minute
„	1	„	„	1·1739	„	per hour
„	851·8	„	„	1	kilogram	per hour
„	386·4	„	„	1	lb.	per hour

A new chapter (XIX.) has also been added on the coupling of two or more dynamos in one circuit. The author justly ascribes to M. Gramme the merit of having pointed out how two series dynamos may be coupled in parallel, but when speaking of the coupling of several compound machines the reader receives the impression that this was first done by Mr. W. M. Mordey, and is, in fact, a new discovery. Such an impression would certainly be erroneous, for in an installation erected by Messrs. Crompton and Co., at Berechurch Hall, in 1882, four compound machines were coupled precisely in the manner described by the author. As regards the coupling of alternate current dynamos, the reader will find in Chapter XIX. a most interesting and clear description of the various phenomena which present themselves, and of the experiments carried out at various times by Wilde, Hopkinson, and Adams. The chapters treating of the "Dynamo as a Motor," of "Theory of Motors," and of "Electric Transmission of Energy" remain as they were. We trust that in a future edition they may receive the same attention as those on dynamos. As they stand they are of little practical use, as too much stress is laid on the question of electrical efficiency quite irrespective of the commercial efficiency. It would also be well to finally abandon the figure 746 as representing the number of watts corresponding to one horse-power. We know from Lord Rayleigh's determination of the ohm and volt that the exact figure, neglecting fractions, should be 736, and think it high time that the correction should be made in all new books. Speaking of the government of motors when supplied with a constant current the author states that a constant speed at variable loads can be obtained by any of the following three combinations:—

(*a*) Magneto motor with shunt regulating coils.
(*b*) Series motor with shunt regulating coils.
(*c*) Series motor with long shunt regulating coils.

All these are based upon the critical condition, as regards speed and external resistance, if the motor be used as a dynamo. In basing his theory on the critical condition the author has evidently overlooked the fact that, although a dynamo has a critical speed at which it will begin to magnetise and produce a current, a motor has no critical speed, because its field is produced by a current from an external source, and that all theories based upon the assumption that a motor will develop counter electromotive force only after the critical speed has been exceeded must lead to wrong results. It is questionable whether the problem of governing motors which are supplied with a constant current can be solved at all by compound winding; in all probability it will be found that something more is required in the shape of some external regulating apparatus. Whatever be the scientific aspect of the question, the broad fact remains that, whereas motors have been made which regulate fairly well when supplied with a constant E.M.F., nobody has, as far as we know, yet succeeded in constructing a self-regulating motor when the condition of supply is a constant current. We hope in a future edition Prof. Thompson will treat the question more exhaustively.

The appendices have been considerably increased in number and also in interest. The latest theories of other writers on dynamo machines are given, as well as some experimental evidence and data from actual practice. An excellent description of the different electric governors in use will also be found here. Appendix XI. contains some statistics of recent dynamos, and is therefore of great practical value. We feel indebted to the author for having given this information, but we sincerely wish it were fuller. It is probably not his fault that the list is very short; makers are, as a rule, very unwilling to let authors have full information, and Prof. Thompson has done the best he could with the material accessible to him.

The book, as a whole, will be found extremely useful to the practical student. It has all the merits of the former edition, and in addition the merit of being brought as nearly up to date, as regards dynamos, as the rapid progress in this branch of applied science will permit. If we have ventured to criticise some parts of it, and especially the part concerning motors, it is because we wish to see in a future edition the whole problem of motors treated more exhaustively, and because we feel convinced that the author would, if he chose, be fully equal to the task.

ELECTRIC HEADLIGHTS.—Recent experience in Russia appears to show, says *Nature*, that financial considerations are not alone unfavourable to the system of electric headlights for railway engines. On the railway between St. Petersburg and Moscow several locomotives were fitted with electric lamps. For a time they gave great satisfaction, lighting the way more than a kilometre in front. But the *employés* began to complain of the contrast between the lighted and the unlighted surfaces painfully affecting the eyes; and doctors ere long reported that there had been several cases of grave injury to the eyes in this way. Hence the lamps were abandoned. The directors have not, however, given up the idea of better illumination of the line; and they now contemplate placing the electric lamps so as to illuminate about a kilometre on either side of the station.

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THE ELECTRICIAN.

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All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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ANSWER TO CORRESPONDENT.

MIDGE.—*You have not sent your name and address.*

TWO ELECTRIC LIGHTING COMPANIES.

Of the electric lighting undertakings which have survived the storms and wreckage of the past four years, two important ones, the ANGLO-AMERICAN BRUSH CORPORATION and the MAXIM-WESTON COMPANY, have recently held meetings, at which information was given not wholly unsatisfactory. There remain besides, several companies and private firms engaged in the business as prosperously as ever; and some other corporate concerns which have started more recently on different lines, profiting by the experience of their predecessors, seem to have an encouraging future before them. But of the countless host which entered the field of operations in the heyday of its promise, scarcely any have retained their identity or escaped annihilation except the companies referred to. But when we have said this we have said the worst; for the very fact that they retain any vitality at all under the extremely adverse circumstances they had to contend against is proof not merely of the merits of the system they have severally been promoting—which is a matter affecting chiefly the pockets of their shareholders—but also that the business of electric lighting is not wholly discredited, which is a matter that more generally concerns the British public. We all know perfectly well what have been the causes of the many failures, so complete and disastrous; that some few adventures have escaped the general fate is a thing almost to be wondered at, and is on that account all the more a subject for hearty congratulation.

The step which the MAXIM-WESTON COMPANY have now taken by again striking off their unrepresented capital in order to enable them to pay a dividend is one for the shareholders alone. At first sight the process looks like throwing the biscuits overboard to lighten the boat; but if in reality what once represented stored provisions prove to be nothing but empty tubs, the sooner they are cast adrift the better. It is represented that a satisfactory dividend has been earned during the year on legitimate business worked by the existing capital, and to this the shareholders have preferred a claim. Both in their immediate interests and for their future chances of enhancing the market value of what remains of the original investment the reduction of the nominal capital to its actual dimensions, though a questionable operation at best, is the course that seems wisest in their eyes. With a valuable system such as the MAXIM-WESTON COMPANY undoubtedly possess, their operations ought now to be remunerative; and if, as is alleged, considerable profits have been made in recent months notwithstanding the amount of plant thrown on the market by companies in liquidation, the shareholders may confidently look with renewed hope to the results of fresh contracts for the current year.

With the BRUSH ELECTRIC LIGHTING CORPORATION affairs seem to be even more reassuring. The business meeting of this company on the 10th inst. revealed that besides some absorption of minor undertakings, obviously to the advantage of all parties, the remunerative work carried out during the past year was considerably over that of the preceding year; while work which at first had been undertaken and kept on at a loss is now beginning to yield a profit. The Annual Report was itself highly gratifying, and the Chairman's speech at the meeting still more so. He is in complete possession of the facts on which his estimate is based; and his confidence in the future prospects of the undertaking over which he presides was apparently shared by those who listened to him. Some changes have been made in the *personnel* of the management which betoken no falling off in energy and vigilance. Exception might very well be taken to the line of business taken up conspicuously by this corporation for purposes of advertisement rather than gain in its earlier career; but it must be confessed that those who were responsible for it may now retort that it has paid in the long-run. The BRUSH COMPANY is foremost at all the great exhibitions—though it has not secured the Folkestone installation as it reckoned upon—and is the chief competitor for street lighting almost everywhere. It has virtually secured the lighting of the City of London on an extended scale, and at prices which, while not so high as to discourage invitations from other localities, are sufficiently so to enable the company to earn a profit. With its foreign business relations we are not so much interested, though they are extremely gratifying to the shareholders; but it is satisfactory to note that an English company is going to take to Berlin an article of consumption more genuine and less dangerous than the cutlery and bayonets which have lately been shipped to us from that quarter. If for no other reason we wish for this that the Brush Electric Light may inflict on the German capital an honourable revenge for British wrongs.

Both the companies we have referred to are counting upon a speedy repeal of the obnoxious clauses in the Electric Lighting Act. But for that malignant piece of legislation electric lighting industry would by this time have been in a position

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far more promising and probably even flourishing. It is said that the late Government were willing to extend the confiscation clause from twenty-one to forty years. We are glad that the Directors of these Companies are holding out for an entire abolition of this provision. It is vicious in principle, and ought to be fought out on commercial grounds, if on no other. We cannot expect for electric lighting privileges which are granted to no other industrial undertakings; but we have a right to ask for the same privileges, and to protest against new political doctrines of questionable soundness and unquestionable immorality being applied to us because we happen to be the latest comers on whom an experiment can be tried. LORD SALISBURY'S declarations on this point were statesmanlike and fair all round; whether we sit on his side in politics or not it is surely a matter of the deepest interest to capitalists of all parties that the doctrine of ransom shall not be applied to industrial enterprise generally, as it certainly will be if the prospective seizure of electric lighting property should prove successful. We are glad to learn that this question is to be brought by LORD RAYLEIGH before the House of Lords, where it will have a chance of being honestly dealt with; and by the Chairman of the MAXIM-WESTON COMPANY in the House of Commons. If the objectionable clauses of the Act, one relating to the form of lamp, and the other to the confiscation of property, but especially the latter, could be got rid of, we should have no fears for the future of electric lighting; and the present financial condition of the two companies whose affairs we have been discussing goes a great way to support us in this confidence.

STREET RIOTS AND THE TELEGRAPHS.

On that part of Mr. Childers' Committee's Report relating to the employment of the telegraph in cases of public disturbances we venture to remark that London has never yet been in a state of siege like that pre-supposed by a scheme of the kind suggested. It was hardly to be expected that a civil force would take precautions such as could enter the minds of none but military men, and for an occasion when nothing worse was anticipated than a scrimmage between two hostile meetings where there was plenty of room to fight it out. The fact is, the diversion westwards of the worst elements in the crowd was a surprise to everybody, including probably the instigators who are now on their trial at Bow-street. If riots of similar seriousness are as infrequent in the future as they have been in the past, any arrangement for utilising the telegraph or telephone in cases of emergency would soon become a dead letter and altogether illusory. A signal for "clearing the line to Scotland-yard" is all very well from Lord Wolseley's point of view; but in reality it would drop out of memory through never being used. Of course, if we are to expect a regular recurrence of these disorders it may be as well to organise a street telegraph to Police Depots, just as we have done to the Fire Brigades. Short of this we do not see the utility of conferring powers which would be inoperative unless, as in the case of fires, frequently exercised. The Committee also make a great blunder in supposing that telegraphs designed for ordinary traffic and for long distances can be instantaneously used with advantage for short distances, such as those mentioned in the Report. There should be no delusion on this point. A mounted policeman will beat the telegraph easily for any distance under four miles. It was the absence of mounted patrols that led to all the mischief, and their presence at future demonstrations will adequately prevent any rioting without the help of the telegraph.

CORRESPONDENCE.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am obliged by your publishing my letter of the 15th inst., and also for your note appended to it. It is now manifestly the duty of "Hamlet" in the interest of science to give in your columns the following information :—

First. What kind of electrical apparatus was used?

Second. How was the electricity conveyed to the boy's body?

Third. What is the name and address of the man, seeing "Hamlet" says "he knew the man."

By "Hamlet's" giving the above information he will open a door for faith in his story.—Yours, &c.

JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, February 20, 1886.

P S.—I forgot to state that there were two electric boys publicly exhibited in this city; one of them was admittedly electrified by external means, the other, I maintain, was not electrified by external means.

TELEPHONIC RECEIVERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Would you or any of your correspondents kindly acquaint me through the medium of *The Electrician* with the nature of the composition used in the formation of the cylinder in the Edison receiver. I believe there is a type which does not require the application of moisture; of this, I would specially feel obliged for some information.—Yours, &c.,

Feb. 20, 1886. J. S. H.

DIRECT AND COUNTER ELECTROMOTIVE FORCES REPRESENTED BY AN HYPERBOLA.*

BY H. S. CARHART.

In the usual discussions respecting the relations between the electromotive force (E.M.F.) of the generator, the counter E.M.F. resulting from the electromagnetic reactions taking place in the motor, and the rate at which energy is absorbed by the latter in the electrical transmission of power, it is implicitly assumed that E is constant. Thus the equation, representing the division of the whole electrical energy spent in the circuit in unit time into heat and mechanical work, viz.:

$$C E = C^2 + W_{,}$$

is differentiated so as to obtain the first differential coefficient of $W_{,}$ with respect to C, R and E being constants. Hence $\frac{d W_{,}}{d C} = E - 2 C R = 0$ for a maximum, the second differential coefficient being negative. C is therefore equal to $\frac{E}{2 R}$, or the current is reduced to half the value it would have with the motor at rest, by the reduction of the effective E.M.F. to one half.

If, however, we take the equation expressing the electrical energy absorbed by the motor per second as the product of the counter E.M.F. and the current, we have, as is well known,

$$\frac{E_{,}(E - E_{,})}{R} = W_{,} \text{ or } E_{,}(E - E_{,}) = R W_{,} \quad . \quad . \quad . \quad (1)$$

From this it appears that if R and $W_{,}$ and constants, $E_{,}(E - E_{,})$ is also a constant. But when the product of two factors is a constant, their sum is a minimum when they are equal to each other. It follows that the sum of $E_{,}$ and $E - E_{,}$, or E, is a minimum, when $E_{,} = E - E_{,}$ or when $E_{,} = \frac{1}{2}E$. By substitution in equation (1) $E_{,} = \sqrt{R W_{,}}$.

* American *Journal of Science*, February, 1885.

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With an assumed amount of work spent upon the motor per second and a given resistance R, E has a minimum value equal to twice $E_{\prime}$. This correspond's with Jacobi's law of maximum rate of working, or greatest electrical activity and constant E.M.F. Evidently the conditions of greatest activity and constant E.M.F. of the generator are identical with those of constant energy absorbed by the motor and minimum E.M.F. of the generator.

Equation (1) gives

$$E_{\prime}^2 - E E_{\prime} = - R W_{\prime} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

an equation of the second degree and therefore of a conic section. On applying the proper criterion it readily appears that the locus of this equation is an hyperbola. For the purpose of a graphical representation of the continuous relation between E and $E_{\prime}$, let us assume R $W_{\prime}$ equal to 225; minimum E will then equal 30 units.

Solving equation (2) for $E_{\prime}$ and substituting in the result successive different values of E as the independent variable, we obtain corresponding values of $E_{\prime}$ which satisfy the equation. Each assumed value of E gives two plus values of $E_{\prime}$. The hyperbola I is thus plotted, making the assumed values of E abscissæ and the corresponding ones of $E_{\prime}$ ordinates. $E_{\prime}$ is considered essentially positive.

By a comparison with the most general equation of a conic section, the constants of this particular one may be determined.

Thus, independently of the assumed value of R$W_{\prime}$, $e^2 = 4 \pm \sqrt{8}$ and $e = 1{\cdot}0824$, the other value of e making n imaginary. Also, $\cos a = \pm \frac{1}{e}$ and $a = 22° \; 30'$, the minus value of the cosine not being admissible because then m would become negative. But all values of E are positive, and hence m cannot be negative.

Since the cosine of the angle between the transverse axis of an hyperbola and its asymptotes is the reciprocal of e, it follows that the asymptotes of this curve are the axis of X and the diagonal O G, the angle between them being 45°. The character of the curve is thus entirely determined without knowing the value of R$W_{\prime}$.

Assuming now R$W_{\prime}$ equal to 225, the co-ordinates of the focus are $m = 32{\cdot}96$ and $n = 13{\cdot}65$.

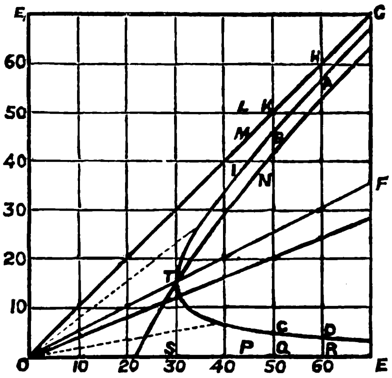
It is evident also from the properties of the hyperbola that m and n in this case equal A and B respectively. The perpendicular distance of the directrix from the origin is 30·45.

A number of inferences can be drawn directly from the curve by inspection. It is seen that E is a minimum when it is double $E_{\prime}$. At this point the hyperbola is tangent to an ordinate; the point of tangency will travel along the line O F, away from the origin or towards it according as the assumed value of R$W_{\prime}$ increases or diminishes. O F is therefore the line of minimum E, and its equation is $E_{\prime} = \frac{1}{2} E$.

The electrical efficiency at any point of the curve, being the quotient of $E_{\prime}$ by E, is the tangent of the angle which a line drawn from the point to the origin makes with the X-axis. The efficiency of T is the tangent of the angle T O E, or one-half. The electrical efficiency increases from zero, when $E_{\prime}$ is zero and E is infinite, to unity, when $E_{\prime}$ equals E and both are infinite; the angle, whose tangent is the measure of the efficiency, is then the angle between the asymptotes, or 45°, and the tangent of 45° is unity. The limits of the efficiency correspond to the points where the curve touches the asymptotes.

It is also evident that near the point where E is a minimnm $E_{\prime}$ increases most rapidly. That is, near the point where the efficiency is one half it has its greatest increments. Beyond an electrical efficiency of about 75 per cent. the direct and counter electromotive forces increase in nearly the same ratio, and the efficiency, therefore, increases very slowly.

The diagram shows further that $E_{\prime}$ and C pass through corresponding series of values, but in the inverse order. The current is proportional to $E - E_{\prime}$, the resistance being constant; and since the intercepts of a secant between an hyberbola and its asymptotes are equal, that is, A H equals D R for instance, when the counter E.M.F. passes through the series of values represented by the ordinates D R, C Q, T S, B Q, A R in succession, the current will be proportional to A R, B Q, T S, C Q, D R in succession. With the condition that the motor absorbs a constant amount of energy per second, the current is a maximum when the counter E.M.F. and the electrical efficiency are a minimum; and it diminishes continuously as the efficiency increases.



E and $E_{\prime}$ denote direct and counter electromotive forces; C current and R resistance in circuit connecting generator and motor; W the total electrical energy contributed by the generator, and $W_{\prime}$ the electrical energy absorbed by the motor in unit time; c the eccentricity; A and B the semi-axes; m and n the co-ordinates of the focus of the hyperbola; a the angle between the axis of X and the axis of the conic section.

If, now, the constant chosen is not the rate at which energy is absorbed by the motor, but the electrical energy contributed by the generator per second, we then have the equation

$$C E = \frac{E(E - E_{\prime})}{R} = W, \text{ or } E^2 - E E_{\prime} = W R \quad . \quad (3)$$

This is again an equation of the second degree, and its locus is the hyperbola I I. Its axis makes an angle of 157° 30′ with the axis of X, and its asymptotes are O G and the axis of Y. Its eccentricity is 2·613, the second value obtained from the equation $e^2 = 4 \pm \sqrt{8}$, the other value being the eccentricity of hyperbola I.

In this case the two machines and the conductor joining them form a system the only condition laid down being the constancy of R W. Hence the relation between E and $E_{\prime}$ may be found either when the motor is driven by the current and furnishes counter E.M.F., or when it is driven by mechanical means so as to contribute to the direct E.M.F. If the motor is actuated by the current, then E has its minimum value when $E_{\prime} = 0$, or at the point where the hyperbola crosses the axis of X; but if the motor dynamo contributes E.M.F. in the same direction as that of the other machine, then E may diminish still further, even to zero in the limit. In this case R W represents still the energy furnished by the generator, but not the total electrical activity per second. The part of the hyperbola lying below the axis of X corresponds to values of E and $E_{\prime}$ obtained when the motor is driven mechanically so as to furnish direct E.M.F.

In the first curve any assumed value of E greater than the minimum gives rise to two values of $E_{\prime}$, both positive. In the equation of the second curve the substitution of a positive value of $E_{\prime}$ gives two values of E, one positive and the other negative, indicating another branch to the curve. This other branch represents the relation between E and $E_{\prime}$ when the part played by each machine is reversed, the motor becoming the generator, and the generator becoming the motor by being driven electrically.

In curve two the efficiency is measured in the same way as before. Again it is seen to increase as the electromotive forces increase. The current, represented by the intercepts of the ordinates between the hyperbola and its asymptote O G, decreases as the efficiency increases. The same was true in the other case.

It remains only to point out that Jacobi's law of maximum rate of working applies only under the condition of a constant E.M.F. in the electric supply. This will be evident upon careful inspection of the diagram. The energy spent upon the motor per second is represented by $E_{\prime}(E - E_{\prime})$; the electrical energy supplied by the source per second by $E(E - E_{\prime})$.

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The first expression is the product of the two parts into which the line denoting E is divided at any point by curve I. Since O G bisects the angle between the two rectangular axes, the ordinate of any point of this line equals the abscissa of the points of the hyperbola through which it passes. Thus K Q equals O Q or E, the direct E.M.F. corresponding to the points B and C of the curve. Hence B K equals $E - E_{,}$; and the product of B K and B Q, or the area of the rectangle B M P Q, is the constant R $W_{,}$ of the equation of this hyperbola. The area of all such rectangles is the same for this curve. In a similar way the area of K L P Q is the rate at which electrical energy is supplied to the circuit; and the difference between the two rectangles, or the square K L M B, is the heat waste per second at this point of the curve.

Now, while the area of the first class of rectangles is the same for all points of the curve, that of the second and of the squares diminishes as $E_{,}$ and the efficiency increase from point to point along the curve in the direction D, C, T, B, A. If the same analysis is applied to curve I I it will be found that the area of the rectangle expressing the electrical work spent upon the motor per second increases, the rectangles denoting the rate at which energy is supplied by the generator all equal R W, and the area of the square representing the waste in heat diminishes from point to point, as E, $E_{,}$ and the efficiency increase. We may therefore distinguish three cases, R being constant in each case :—

First, when E is constant.
Then $W_{,}$ is a maximum when $E_{,}$ is half E by Jacobi's law.
The electrical efficiency increases with $E_{,}$.
The current diminishes as $E_{,}$ increases.
W diminishes from a maximum to zero when the efficiency is unity.

Second, When $W_{,}$ is a constant.
Then E is a minimum when $E_{,}$ is half E.
The electrical efficiency increases with $E_{,}$.
The current diminishes as $E_{,}$ increases.
W diminishes from infinity to $W_{,}$ when the efficiency is unity. These are the limits.

Third, When W is a constant.
Then $W_{,}$ is a maximum only when the efficiency is unity, in which case E and $E_{,}$ are infinite.
E has a minimum value of $\sqrt{RW}$ when $E_{,}$ is zero.
(The case of the motor driven mechanically is not included.)
The electrical efficiency increases with $E_{,}$.
The current decreases as $E_{,}$ increases.

Jacobi's law applies only to the first case. When a battery is to be employed to run an electric motor, then E is the proper term to consider constant; but if it is required that the motor furnish a definite amount of power, then the graphical illustration of hyperbola, I, shows that E has a minimum value and points out some of the conditions of high efficiency.

DYNAMO TESTS.*

(Continued from page 254.)

It was intended to determine by experiment the specific heat of the specimens of the iron used in the calorimeter, but circumstances made this impossible. The value used,

·112,

is taken from determinations by Bystrom, Weinhold, Regnault, and Bede, reduced to 30deg. C. The values given by these different experimenters agree very well, and it seems probable that the mean does not differ from the specific heat of the iron used in the calorimeter by more than one or two per cent. at the most—an error that enters as about one-tenth in the result.

The weighings were made with a scale beam by Fairbanks. Both the weights and graduation had been tested. The results obtained are given in Table A following.

* From the *Journal* of the Franklin Institute.

TABLE A.

	lbs.
Weight of calorimeter alone	1228·75
Weight of calorimeter with water...........	2451·75
Weight of water..	1223·0
Water equivalent of the iron..................	137·62
Total water equivalent	1360·62
Correction for weighing in air	1·38
Water equivalent, corrected	1362·00

Temperature Observations.—The thermometers used were those by Green, already described. The time the mercury crossed each half degree was observed, and was taken as the mean of the times of crossing the tenths below and above the division, and the division itself. The times were noted by a chronometer.

The following table gives the temperature observations and the dynamometer readings—the latter were taken each minute:

Calorimeter Observations for Checking Dynamometer, June 27.

TEMPERATURE.	Observed Time of Crossing Division.	Corrected Time of Crossing Division.	Intervals for 4·5°C.
30·5	12—01—44·	12—01—44·	
31·	02—20·2	02—20·3	
31·5	02—57·0	02—56·8	
32·	03—33·3	03—33·3	
32·5	04—09·6	04—09·7	
33·	04—46·0	04—46·3	
33·5	05—22·3	05—23·1	
34·	06— 1·6*	06—00·2	
34·5	06—37·6	06—37·3	
35·	07—14·0	07—14·4	5—30·4
35·5	07—51·6	07—51·6	5—31·3
36·	08—29·0	08—29·0	5—32·2
36·5	09—07·3	09—06·2	5—32 9
37·	09—43·3	09—43·4	5—33·7
37·5	10—20·3	10—20·6	5—34·3
38·	10—58·0	10—58·0	5—34·9
38·5	11—36·0	11—35·5	5—35·3
39·	12—13·0	12—13·0	5—35·7

* Untrustworthy, only one reading.
The times were corrected arbitrarily by the observations on either side.

Dynamometer Readings.

TIME.	Counter.	Scale Beam.	Friction.
12—01—00	0159		
02—00	0881	665	13·72
03—00	1603	666	13·72
04—00	2326	664	13·72
05—00	3042	661	13·72
06—00	3761	661	13·72
07—00	4479	661	13·72
08—00	5198	663	13·72
09—00	5916	666	13·72
10—00	6640	666	13·72
11—00	7360	666	13·72
Mean:	720·1	663·9	13·72

The corrections to be applied to the thermometer readings are for the part of the stem in the air, and for radiation. The first of these is somewhat indefinite, as a portion of the stem is heated by conduction from the calorimeter. The whole correction, however, is only about one-third per cent., and its value is probably correct within twenty or thirty per cent., so the error in the result from this cause can hardly be much over $\frac{1}{10}$th per cent.

But the most important correction, and the one in which there seems the greatest possibility of error, is the coefficient of radiation. This is usually determined by slowly stirring the calorimeter, and noting its difference of temperature from the air and rate of cooling, correcting for the heat developed in stirring. But with a single thin blade, and no arrangement for causing circulation, this method was impracticable. In some experiments that were tried, the water was not thoroughly mixed, and the cool water falling and warm water coming to the top, made the values obtained worthless.

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Under these circumstances, it became necessary to calculate the radiation from the experiment for the determination of the mechanical equivalent.

The method of calculation was as follows:—The observations were divided into intervals of 4·5deg. C., as shown in the following table, and the corresponding intervals of time were reduced to the same rate of doing work, the same value of the specific heat of water, and the same value for the stem correction of the thermometer. The remaining difference in the intervals is assumed to be due to radiation.

Calculation of Radiation.

Interval.	Time Interval Uncorrected.	Ratio of Rate of Doing Work to Mean Rate.	Correction for Specific Heat of Water.*	Correction for Stem in Air.*	Time Interval Corrected.	Excess over First Interval.
degrees.	minutes.	×	÷	÷	minutes.	minutes.
30·5—35·	5·5067	1·00145	1·00000	1·00000	5·51467	·00000
31· —35·5	5·5217	1·00026	1·00000	1·00016	5·52224	·00757
31·5—36·	5·5367	·99957	1·00010	1·00032	5·53200	·01733
32· —36·5	5·5483	·99885	1·00020	1·00048	5·54196	·02729
32·5—37·	5·5617	·99847	1·00031	1·00065	5·54808	·03341
33· —37·5	5·5717	·99824	1·00040	1·00081	5·55630	·04063
33·5—38·0	5·5817	·99980	1·00050	1·00097	5·57250	·05783
34· —38·5	5·5883	1·00134	1·00060	1·00113	5·58607	·07140
34·5—39·	5·5950	1·00219	1·00070	1·00130	5·59600	·08133

Gives radiation ·00258° per degree per minute.

* These are the ratios of each succeeding interval to the first interval.

The differences of these corrected intervals from the first interval were plotted, the excess of the mean temperatures of the intervals over that of the air being taken as abscissæ, and the above differences as ordinates. A straight line was drawn through the points thus found. The radiation was calculated by taking the difference of the ordinates for an interval of 4°, and from this value (which is the loss of time due to radiation, in an interval of about 5·55 minutes, the difference of temperature being 4°) the coefficient of radiation was easily found.

In drawing a straight line through the points, we have assumed the coefficient of radiation to be constant when the excess of temperature over that of the air varies, instead of increasing with the excess. Within the rather narrow limits of temperature used, however, the value found represents very nearly the radiation for the mean interval. In calculating the experiment by the second method, the value of the radiation found above was corrected to the greater difference of temperature between the calorimeter and air, by increasing it in the ratio shown by the experiments of McFarlane and Rowland.

This method of calculating the radiation, while not so accurate as the method usually employed, has the advantage that the conditions of observation are accurately those of the experiment to which the radiation is applied.

It will be seen that the errors likely to affect the radiation coefficient are errors of observation, in the relative values of the specific heat of water at the different temperatures, and in the ratios of the stem corrections.

As for errors of observation, the dynamometer readings for the intervals were the mean of five observations, and, although the jar interfered somewhat with the readings of the thermometer, yet the table shows that there were no very great errors, and the method of observation allowed the readings to be to some extent corrected by those on either side.

The ratios of the values of the specific heat of water for the different intervals were calculated from Rowland's values of the mechanical equivalent for the mean temperatures of the intervals. Fortunately the correction was small, and probably accurately given.

Whatever the absolute value of the stem correction might have been, there could be little error in the relative values for the different intervals.

The result obtained was :—

Excess of cal. over air, 4° C.	coefficient of radiation, ·00258
8° C.	·00262

On applying the above values to the observation by the first method, we obtain :—

Mean rise of temperature, per minute (uncorrected)	·809814
Mean correction for radiation,	+ ·017790
Mean correction for stem,	+ ·003034
Mean correction to absolute temperature,	− ·001350
Mean rise, per minute (corrected)	·822288
Water equivalent of calorimeter,	1362 0 pounds.
Heat units developed, per minute,	1119·9562
Mean reading scale beam,	663·9
Friction reading scale beam,	13·72
Difference reading scale beam,	650·18
Mean revolutions,	720·1
Work in foot pounds = product × 3·3 × 1·0025	15489048
Mechanical equivalent for 1° C.,	1383·01 ft. lbs.
Mechanical equivalent for 1° F.,	768·34 ft. lbs.

Unfortunately, however, the construction of the calorimeter made the results of this experiment untrustworthy. The blades were kept apart by pieces of 4-in. pipe, ⅛ in. thick, fitting over the shaft between them. In the space between the shaft and pipe were about five pounds of water not in circulation with the mass in the calorimeter. The shaft being jacketed with this layer of water must have gained heat but slowly. The result was that the heat units calculated were too great, and the mechanical equivalent too small. It is also probable that this effect would make the coefficient of radiation calculated from this experiment slightly too large.

We can only say of this experiment, then, that the value is

768·3 + an indeterminate correction.

Second Method.—In this method water was made to flow continuously through the calorimeter. The engine was run

Continuous Calibration.—Tatham Dynamometer, June 27, 1885.

Time.	Mean Temperature. Exit.	Mean Temperature. Entrance.	Increase.	Weight H_2O	Heat Units.
11·02					
·06	39 528	23·82	15·708	287·25	4512·123
·10	39·5975	23·8225	15·775	267·00	4211·925
·14	39·65	23·8125	15·8375	261·25	4137·546875
·18·30	39·7125	23·815	15·8975	293·75	4669·890625
·22	39·7025	23·82	15·8825	235·00	3732·3875
·26·30	39·67	23·8025	15·8675	310·50	4926·85875
·30	39·645	23·80	15·845	228·75	3624·54375
·34	39·6125	23·80	15·8125	271·25	4289·140625
·38	39·6150	23·805	15·810	274·00	4331·94
·42	39·5875	23·8025	15·785	270·75	4273·78875
·46	39·5875	23·8275	15·76	274·00	4318·24
·50	39·5375	23·845	15·6925	276·00	4331·13
·54	39·52	23·8525	15·6675	275·00	4308·5625
·58	39·485	23·84	15·645	276·00	4318·02
12·02	39·4450	23·84	15 605	277·75	4334·28875
·06	39·3425	23·85	15·4925	289·00	4477·3325
·10	39·255	23·86	15·395	286·25	4406·81875
·14	39·1425	23·8825	15·26	287·00	4379·62
·18	39·0775	23·8925	15·185	284·75	4323·92875
·22	39·0125	23·90	15·1125	284·00	4291·95
·26	38·98	23·91	15·07	289·25	4358·9975
·30	38·895	23·91	14·985	287·50	4308·1875
·34	38·865	23·91	14·955	290·50	4344·4275
·38	38·78	23·905	14·875	293·50	4365·8125
·42	38 8175	23·915	14·9025	275·50	4105·63875
·46	38·93	23·925	15 005	272·25	4085·11125
·50	39·04	23·925	15·115	270·50	4088·6075
·54	39·175	23·94	15·235	265·50	4044·8925
·58	39·3175	23·925	15·4225	263·50	4063·82875
1·02	39·405	23·9125	15·4925	271·00	4198 4675
·06	39·45	23·9025	15·5475	273·25	4248·354375
1·10	39·4825	23·90	15·5825	272 50	4246·23125
·14	39·485	23·92	15·565	273·00	4249·245
·18	39·4925	23·92	15·5725	268·00	4173·43
·22	39·525	23·905	15·63	267·50	4178·35
·26	39·51	23·90	15·61	274·75	4288·8475
·30	39·52	23·895	15·625	268·00	4187·5
Total number heat units					157735·96550

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until the temperature of the exit water ceased to rise, and then observations of the entrance and exit temperatures and of the dynamometer were taken each minute, and the exit water weighed every four minutes. The weighings were made by two of Fairbanks' platform scales that had been tested with standard weights. The observations lasted one and one-half hours. The heat units were calculated for each interval of four minutes, as shown in the table, and their sum taken for the whole interval. The scale reading and number of revolutions of the dynamometer were averaged for the time of the experiment, the work being calculated from the means (Philadelphia time).

When the experiment was finished, the two cocks on the calorimeter were closed, and the engine stopped. The temperature of the water was then found to be 39°. The time occupied in stopping was about four minutes, equivalent to two minutes on full load. From the data of the previous experiment, the rise of temperature would be about ·85° C. per minute, and therefore the average temperature of the calorimeter during the second experiment was about 37·3°.

(To be continued.)

DUNDEE NATURALISTS' SOCIETY.

On Saturday last the members of this Society gave a *conversazione* in the University College, Dundee. During the course of the proceedings, Mr. Thomas Reid, who had charge of the engineering department in the absence of Prof. Ewing, gave a short address in the engineering lecture room on the storage of electrical energy. He pointed out the causes which necessitate some means of storage, explaining the conversion of energy which takes place in charging and discharging the batteries, the application to lighting, and the driving of tramcars, &c. In the department of mathematics and natural history a number of very interesting experiments were made during the course of the evening. These included the lifting of a 28lb. weight by a train of wheels connected with a small Griscom motor; the effect of the electric current on a large electro-magnet; the lighting of a small tank at the will of the visitor by electric lamps burning under water, and the apparently still appearance of a rapidly turning disc with coloured sections when viewed by the electric spark from a Wimshurst machine. Experiments in light and sound took place in some of the smaller rooms. In the electrical engineering laboratory there was a fine display of apparatus. The practical application of electricity in the transmission of power to a distance was illustrated by means of a turning-lathe driven by an electromotor, the current being supplied from a dynamo driven by a gas engine in the workshops, and conducted by wires to the motor. The drawing office, which was shown as in general use, was lighted by 10 candle-power incandescent lamps, one to each table, suspended from the roof by a method designed by Mr. Reid, which allows the lamp freedom of movement in every direction over the table, thus avoiding shadows. The lamps are supplied with current from secondary batteries. The instruments designed by Prof. Ewing for measuring earth movements on Ben Nevis were exhibited in the corridor, and carefully inspected.

THEORY AND APPLICATION OF THE TELEPHONE.

A lecture on this subject was recently delivered in the Burgh School, Kirkcaldy, by Mr. Townsend, district manager of the National Telephone Company for Fifeshire. The lecture was illustrated by apparatus and experiments. The lecturer began by referring to the early means of communication, and gave a short descriptive sketch of the origin and development of the telegraph. He then said the idea of transmitting the tones of the human voice from one place to another by artificial means is not of recent date. We are told that the Chinese, that wonderful race of people in the east, claim to have invented the telephone, and they do so on the strength of a book written by one of their ancient philosophers. The Persians said that the telephone had been for ages the toys of their children, and it has been found that the telephone of the Persians was identical with what is now called the "mechanical telephone." Two small cylindrical boxes are connected together by means of a tight string, and when speech is uttered into one of the boxes it is reproduced in the other. Its mechanical difficulties, however, prevent it being brought into practical use, and it therefore cannot be compared with the electrical telephone. The electrical telephone was invented by one Phillip Reis, a teacher of natural science in Germany, in 1861; but he was not successful in bringing his instrument before the public, and it was not till 1874, nearly twenty-four years after, that the subject received the serious consideration of scientists, and which has resulted in the perfection of his most wonderful instrument, which is destined some day to have the most civilising influence which it is possible for any invention to exert. In 1876 Alex. Graham Bell, a native of Edinburgh, then resident in America, and Professor of Vocal Physiology in the University of Boston, so improved upon it as to make it a practical success. This instrument, which Mr. Bell devised and sent to the Philadelphia Exhibition in 1876, caused a great sensation amongst scientific men, and Sir W. Thomson, who was present, proclaimed it "the most interesting of scientific inventions made in the history of science." The outcome of this perfection has been the establishing of what are called telephone exchanges, and now there is not a city or town of any importance but has, or is going to have, its telephone exchange, and to-day, out of the half-dozen towns in Scotland where the telephone is already established, Kirkcaldy is one of the most promising. One special advantage of the telephone is its great utility in cases of fire. Most large cities have their fire appliances on a large scale, but in comparatively small towns like Kirkcaldy no such system is required. The lecturer then described a fire alarm system as fitted up by the National Telephone Company in Inverness, where it had been of immense advantage. Loud sounding bells were placed in each fireman's house, and connected by wire with an instrument at the police office, which was under the control of the officer there. When a fire occurred in any part of the town a signal was given to the officer at the police office, either by telephone or otherwise, who immediately turns a handle attached to the fire instrument, which at once sets all the bells in the firemen's houses ringing, who know to come at once to the fire station. By this means the brigade can be called out in five or six minutes.

SOME POINTS IN ELECTRICAL DISTRIBUTION.

BY PROF. GEORGE FORBES, M.A., F.R.S.E.

(Concluded from page 298.)

SECONDARY GENERATORS.

I now come to speak of secondary generators, and since the principles which regulate their action are rather novel, it may be well if I spend a little more time in describing their action than I would otherwise do in a lecture treating chiefly of the manner of laying main conductors.

Everyone knows the principle of the induction coil. It consists of a core of iron surrounded by a coil of insulated wire called the primary coil, and by another one of insulated wire called the secondary coil. The secondary usually contains a large number of turns and finer wire than the primary. The current in the primary is alternately made and broken by a simple automatic means. This magnetises and demagnetises the iron core. This is equivalent to introducing and withdrawing a magnet into and out of the secondary coil and sets up currents in the secondary coil.

The electromotive force created in each turn of the secondary coil is measured by the number of magnetisations per second, and by the strength of the magnetisation. The latter is generally proportional to the number of turns in the primary, and to the current flowing through it. Thus the electromotive force in the secondary coil depends (1) on the number of turns in the primary; (2), on the number of turns in the secondary; (3), on the strength of the current in the primary; and (4), on the number of makes and breaks in the primary current. Thus by having a large number of turns in the secondary coil, and a small number in the primary, a very high electromotive force can be obtained from a small battery connected with the primary. If, on the other hand, a high tension interrupted current were sent through the fine wire coil we could get a large current from the thick wire coil.

Now, to feed a number of glow lamps in parallel, we require a large current, but this requires a large conductor. Here it was proposed to use a high tension alternate current (which acts just like an interrupted current) by a thin conductor from the works to the place of consumption, and there to transform it into a current of large quantity.

Then, again, another idea was thrown out. This was to carry the alternate current by a thin conductor round a large district, and at intervals to pass it through the first coil of induction coils, using the second coil to supply the lamps. Thus we should have a high tension current disconnected from the service conductors, and furnishing them all with a low tension current.

Induction coils used in this way have been called secondary generators or transformers. The perfection of manufacture of such apparatus consists in getting a maximum of induction and a minimum of heating. This has been admirably accomplished in the generators of Messrs. Gaulard and Gibbs. Instead of wire, the coils are made of copper discs, or flat rings split at one point, and with ears projecting outwards at the split. These discs alternately belong to the primary and secondary circuit, and successive discs of each circuit have the ears soldered together in such an order as to make up a spiral. The iron core is, of course, made of iron.

Although the even discs belong to the primary and the odd ones to the secondary, it does not follow that alternate discs should be coupled together. We may couple the 1st, 5th, 9th, &c., together, and also the 3rd, 7th, 11th, &c., so as to form two secondary circuits, which may be combined in parallel. The number of possible modifications of this sort is very great.

When the primary coil is magnetising and demagnetising the iron core, the latter sets up a counter electromotive force in the coil, and thus the current is largely diminished. But when there is no external resistance in

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the secondary coil, that coil being short circuited, then any magnetisation and demagnetisation of the core starts a current in the secondary coil, opposite in direction to that in the primary and almost equal to it. Thus the iron cannot get much magnetised, for it is surrounded by two opposing currents almost equal in amount. In this case, therefore, the primary has little or no counter electromotive force opposing it, and consequently it flows more freely. This explains a thing which often puzzles the beginner, viz., that with a constant electromotive force in the dynamo the current in the primary is stronger when the secondary circuit is closed than when it is opened.

Very little energy is expended in magnetising and demagnetising iron wires. Thus there is really no loss of energy in the transformation, except that due to the heating of the conductors of which the coils are constructed, which is equal to the square of the current multiplied by the resistance. The loss of energy, which could not be accounted for, has been shown by Prof. Ferraris to be less than 1 per cent., and the practical efficiency of the generator amounts to as much as 95 per cent.

The theory of the secondary generators is very like that of the alternate current dynamo, if the reversals of magnetism of the armature were given by reversing the currents in the field magnets instead of by mechanical motion.

Coming now to distribution by secondary generators we find we must use the same principles as in direct distribution.

Parallel Distribution.—Let us take this case first. To do this economically we might lead two thin wires over the district and couple secondary generators to them. The condition of being able to have constant electric pressure in the lamps is that the electric pressure at the terminals of the primary should be constant. Here we meet the same difficulty as was experienced in direct supply. Consider three generators—1, 2, 3, Fig. 1. If the lamps are all on in all three cases then the pressure

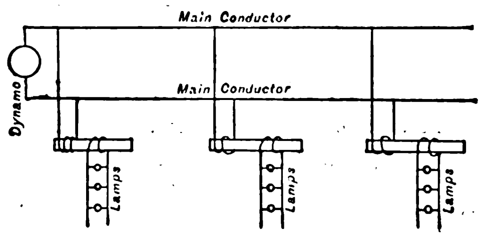

Fig. 1.—Secondary Generators in Parallel.

for No. 3 is less than for No. 2, and that again is less than for No. 1. Suppose you try to rectify this by using lamps of lower pressure at the far station. In this case suppose the lamps in No. 2 are extinguished, then the pressure in No. 3 will go up and tend to injure the lamps. If you try to correct this at the central station you will lower the pressure of No. 1 till perhaps it only burns red. This difficulty is exactly the same as in the direct service. The remedy is of the same kind. You must use the generators as distributing boxes (see my Cantor Lectures, 1885), with separate wires from the engine to each generator, each one being fed with a different pressure from the engine house. Fig. 2 shows this arrangement.

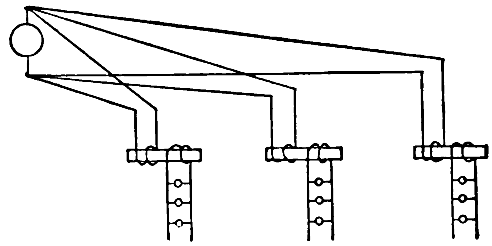

Fig. 2.—Distributing Boxes replaced by Secondary Generators.

There is no objection to it except (1) that you must use a large number of conductors, and (2) you introduce the full pressure of the high tension current into each house.

Finally, we come to distribution by generators in series. Here we have the best effect. A single wire (Fig. 3) goes round the circuit; if a double

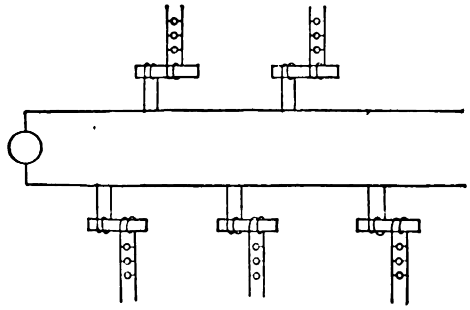

Fig. 3.—Secondary Generators in Series.

wire is used to prevent affecting telephones, it is half the weight, and generators are alternately put on one wire and the other all round the district, and each pair of wires ends at a point far from the station. Suppose we use 10,000 volts, we may have 100 generators in series, each using 100 volts, or we may make any other arrangement. If it were done as I say, then following out the data of my Cantor Lectures, a wire of one square inch section will carry current enough for 100,000 lamps each consuming 60 watts.

In this arrangement we must send a constant current through the circuit. This is actually done by the introduction of resistances. It ought to be done either by an electric governor on the steam engine or by compound winding the alternate current machine, a matter about which there is no difficulty at all.

But how are we to attain to constant electric pressure in the lamps when we have got our constant current? This is a problem which has puzzled many people, and many have come to the conclusion that it is impossible to do it without mechanism. This used to be done by automatically introducing the iron core farther or less far into the coils. It is now done without any relative movement of the parts. This is the last triumph which has been added to a series of laborious experiments which year by year have brought us nearer to a solution of our difficulties. I am not at liberty to explain the *modus operandi*, but I have seen it at work, and it is very satisfactory.

The theory of secondary generators has been so little studied, except by specialists, that I have thought it might be advantageous to many if I added to this paper the formulæ which represent the electric current and pressure as depending upon the resistances and mutual induction of the various parts. These data will be found in the appendix published on next page.

I do not think it would be consistent with the objects of this paper to describe the specific differences between different kinds of secondary generators, or to attempt to give reasons for choosing one of these forms rather than another. I would merely draw attention to the brilliant experiments on self-induction by Prof. Hughes, described in his introductory address as president to the Society of Telegraph-Engineers and of Electricians. Prof. Hughes has discovered a new and hitherto unnoticed source of waste of energy in self-induction, to remedy which it is essential to have the coils of the secondary generator made of discs.

I should also like before leaving the subject to dispel a growing error from the minds of some electricians. In speaking of different secondary generators, some persons are in the habit of speaking of one inventor's generator being used on a parallel system, another on a series system. This distinction is quite illusory. A generator made on any system is equally suitable for all kinds of distribution, and if an inventor states that his generator is only suited for one system of distribution, he displays his ignorance, and shows that he has yet much to learn before he can say he understands the theory of secondary generators.

Last year, when speaking in my Cantor Lectures, I said that the Grosvenor Gallery installation would be followed with interest by engineers. I considered that it was a new test. Up to that time the method had been applied only to light districts where the number of lamps was constant. It was not proved that the method was suitable to the cases where lamps might at any moment be extinguished. Two things were necessary for this—regulation of the current from the dynamo, and automatic regulation of the electric pressure in the secondary circuit. Neither of these had then been accomplished in a manner which satisfied me, and I certainly considered it was a very bold step on the part of Sir Coutts Lindsay to adopt a system which was then so imperfect.

I am satisfied now that self-regulation of the secondary circuit is sufficiently perfect for practical purposes, even when the generators are in series; and I have pointed out to Messrs. Goulard and Gibbs a further development which, in my opinion, will make their system even more perfect. The one weak point in the Grosvenor Gallery installation is the regulation of the current from the dynamo. Out of the four or five different methods by means of which this can be done, the worst has been applied up to this time, viz., hand regulation. The result is a frequent flicker in the lights. Still, when we consider that seven miles of route have been covered by the wires of this small association, and that on the whole great satisfaction is expressed by the users of the light, I must say that Sir Coutts Lindsay and his friends are to be congratulated on the great steps they have made towards success.

In conclusion, I wish briefly to allude to the present condition of electric lighting, and the prospects of economical distribution from central stations.

I have always maintained that there were three causes which retarded the progress of electric lighting:—(1) Financial speculation; (2) the Electric Lighting Act of 1882; and (3) the unsuitability of the schemes of electrical distribution propounded by the contractors. I will say a few words on each in turn.

From the year 1881 to 1883 this country was the scene of a most senseless speculation, started by clever men of business, who took advantage of the interest in electric lighting caused by the Paris and Crystal Palace Exhibitions, and supported by dupes whose ignorance of electrical matters was only equalled by their want of common sense as business men. These men combined to purchase for large sums the right to use the apparatus of some particular manufacturing firm in a special locality. They never asked any competent person whether this firm's apparatus was better or worse than that upon which there were no royalties to pay. Those who were not clever enough to get out of the affair before the bubble burst were the sufferers, and the consequence was a panic in connection with electric lighting which has hardly yet subsided.

With matured knowledge confidence is again being restored, because the public learn from competent and disinterested persons that economical electric lighting can be accomplished without the necessity for paying the heavy royalties formerly demanded.

I trust that the warning of 1882-3 will not be lost on financiers, and that they will not be misled by untried but tempting schemes unsupported by capable men of science.

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The next cause which has deterred electric lighting is the Act of 1882. This is an Act to give undertakers the right to break up streets in order to lay conductors, under certain conditions. It is these conditions which are so unjust. Some of our legislators, looking at the monopolies which exist in gas supply, are afraid that electric lighters will raise another monopoly. Consequently they determined to hamper the electric lighting industry with conditions different to those imposed upon gas, and more stringent. They succeeded well, for they laid down such conditions that no sane man would invest in such a speculation. You would have thought it natural, I doubt not, that if the gas monopoly was truly so very irksome, the encouragement of a rival illuminant would have been the best cure for the evil, whereas our legislators acted as if they were parties interested in maintaining the gas monopoly, for they imposed such restrictions as rendered it impossible for electricity to be supplied to the public. Let me name one of their wise provisions. At the end of 21 years the local authority can, if they please, buy from the company supplying electricity the whole of their plant at the price of old material, without paying a farthing for goodwill or future profits, or past expenses in experimental and unprofitable work.

If, then, a company, after 21 years, were just making headway, and paying a dividend of 5 per cent. on their capital, the corporation would buy them up for perhaps a third of that capital, and get 15 per cent. But the case is even worse if the company is not yet earning a fair dividend, for then the corporation may hang over the company like a usurer over his victim, and each seven years it has the right to purchase the plant or not, and on the same terms as before.

Now, I agree with those who contend that electricity should be allowed to compete with gas under the same disabilities, and with the same advantages. This is not doubling a monopoly; it is splitting it into two, and destroying the monopoly, by allowing competition. If our legislators are not trying to uphold the gas monopoly they must take this view. In any case the public have shown that they will not submit to be deprived by legislation of this illuminant. The Board of Trade, I hear, have perceived their error, and are prepared to yield a little; but if they do not enable us to have electricity supplied to us, we, the public, must force their hand.

Still electric lighting is not quite dependent on this Act. Local authorities have no penalties, and I would strongly urge them to take the matter up, for we have now arrived at a stage when it is safe and profitable to establish electric lighting on a large scale.

Again, you must remember that the disabilities of the Act apply only to those who lay their conductors underground and wish to break up the street. Sir Coutts Lindsay has taught us how to defy the Electric Lighting Act by passing the wires overhead. Those wires do not suffer like telegraph wires in snow storms, for the electric current melts the snow.

The third cause, which deterred the progress of electric lighting, was the unsuitability of schemes of distribution which were proposed. I was impressed with this weak point at an early date. Sir William Thomson was the first to touch on the matter when he announced his law of the economical size of conductors. But the engineer had no tables to guide him as to the safety of these sizes of conductors in the matter of heating. I first attacked this problem in order to clear the way for scientific methods of dealing with distribution. In a paper read before the Society of Telegraph-Engineers and of Electricians, in 1883, I computed from the facts well known to physicists, the heating of different sized conductors with different currents, whether the conductors were bare, insulated, or buried. I had already, in a communication to the British Association in 1882, shown by experimental evidence, that the generally accepted laws required modification when we dealt with small wires.

The way being thus cleared, I attacked the problem of distribution generally, studying the various schemes which had been proposed or put in practice. My conclusions were published in the Cantor Lectures in 1885, and the most useful result was to announce a series of definite rules which must be attended to in order to provide an economical distribution. Since then some progress has been made, and the present paper will, I hope, bring the subject pretty well up to date.

The work which I undertook has been laborious, but it has been a very humble effort. I have brought forward hardly a single fact which could not have been foreseen by the competent engineer. But I think I have saved others from wasting their energy in repeating much of the work, which is laborious; and I also trust that the outcome is a set of rules to guide those engineers whose purely scientific knowledge may be a little defective from falling into the gross errors which have been so apparent in nearly all attempts at lighting by electricity on a large scale which have been made in the past.

I now close the subject for a time, and if the labour I have bestowed upon it leads in any slight measure to establishing one department of electrical engineering on a sound scientific basis, I shall feel that in the work I have undertaken I have been of some little use to my generation.

Appendix.

The following formulæ give the currents and electromotive forces, on the assumption that the magnetism of the core varies as the sum of the currents in the two coils.

The E.M.F. of the dynamo is assumed as being—E sin. mt

Then the primary current $= \mathrm{I} \sin. (mt+\gamma)$

secondary current $= \mathrm{I}' \sin. (mt+\gamma')$

$$\mathrm{I}^2 = \mathrm{E}^2 \frac{\mathrm{C}^2 + r'^2}{r^2 r'^2 + (r+r')^2 \mathrm{C}}$$

$$\mathrm{I}'^2 = \mathrm{E}^2 \frac{\mathrm{C}^2}{r^2 r'^2 + (r+r')^2 \mathrm{C}^2}$$

Where C is a constant;

r = resistance of primary circuit;

r' = ,, secondary circuit.

Also the potentials at primary terminals $= v$;

and ,, ,, secondary terminals $= v'$;

where $v = \mathrm{V} \sin. (mt+\phi)$

$v' = \mathrm{V} \sin. (mt+\phi')$

$$\mathrm{V}^2 = \mathrm{E}^2 \frac{\rho^2 r'^2 + (\rho + r')^2 \mathrm{C}^2}{r^2 r'^2 + (r+r')^2 \mathrm{C}^3}$$

$$\mathrm{V}'^2 = \mathrm{E}^2 \frac{(r'+\rho')^2 \mathrm{C}^2}{r^2 r'^2 + (r+r')^2 \mathrm{C}^2}$$

ρ and ρ' being the resistances of the primary and secondary coils.

Discussion.

The Chairman said he had listened with great interest to Prof. Forbes, and thought that his paper pointed out the way to the electric lighting of the future. There were many authorities there that night on electric lighting, and he thought they could not do better than to take theoretical principles first, and invite Prof. Hughes to give them his ideas on the subject.

Prof. Hughes, F.R.S., said in his latest researches he had found that the maximum induction in iron took place when the iron was in the round form. If it was flattened, so that the contiguous portions of the current became separated from each other, the current was very weak; it had not one-tenth of its previous capacity. In the case of copper wire flattened, the reduction in the self-induction was about 50 per cent. Taking iron wire and passing a current through it, if you wished to have a secondary current parallel to it, the self-induction prevented the current acting on the secondary coil; in fact, the force of the electric current was used up in doing internal work. By flattening it, it reacted on another wire to its full force, so that the energy which would have been used in self-induction was transformed into the secondary current. He had not the slightest doubt that if this method were adopted, enormously more power could be obtained from the secondary coil. When two wires were flattened, the portions contiguous to each other did not react on each other with the same strength, but reacted on any portion near; consequently, when there was another flattened sheet superposed, you had it in the nearest possible proximity. It was very remarkable that the same results at which he had arrived theoretically should have been wo.ked out experimentally by Messrs. Gaulard and Gibbs, and they had arrived at the best possible conditions he could conceive for constructing a secondary coil. He had only one fault to find with it; the generator itself seemed perfect, but it required intermittent currents, and, therefore, it seemed to him there must be a loss in the line. He had been much interested in the paper, and hoped Prof. Forbes would continue his investigations on this subject, which he had made peculiarly his own.

M. Gaulard (who spoke in French) said he was glad to say they had conquered all the difficulties which had stood in their way. The results of their later experiments had been eminently satisfactory. Their apparatus was constructed with two parallel circuits, forming spirals in the same direction. In order to obtain in the secondary circuit a variable electromotive force, they had contrived to unite in parallel and inverse directions the two circuits, and they had found that if in these conditions they sent through them an alternating current, the difference of potential at the ends of the spirals was directly proportioned to the resistance in the leads. If, on the other hand, they interposed in one of the connections a resistance, they found that the difference of potential at the two ends of the secondary circuit was, to a certain extent, directly proportioned to that resistance. From these observations it followed that if the leads consist of two parallel wires, and currents in opposite directions are sent through, not only no phenomenon of induction on the outer external circuit can appear, but no self-induction on these two leads can exist any more. He then detailed some experiments recently carried out by his firm, which proved conclusively the absolute non-existence of self-induction. He thought they might claim to have solved the problem of the transmission of force by electricity.

Prof. Hughes expressed himself quite satisfied with M. Gaulard's explanation. He was not aware that parallel circuits were used.

Mr. Gisbert Kapp, while having nothing to say on the subject of the distribution of electricity, said he would venture to add one more item to the list of improvements in machinery and apparatus. If they were to distribute electricity for the purpose of domestic lighting it was a matter of vital importance that a breakdown should never occur. The best way to prevent a breakdown was to drive at moderate speeds. The present tendency was now in this direction, and they were endeavouring to reduce the speed of their dynamos by making use of stronger fields and better methods of construction. He thought that with reduction of speed the chances of a break down were enormously diminished.

Mr. Drake recounted the advantages possessed by secondary batteries for general lighting purposes. In regard to the secondary generators, he thought that not only would any irregularity of the engine be transmitted to them, but that the variations due to inequality of consumption of different points of the circuit would also be noticeable. As to an indicator for cutting out any number of cells, he thought it was really not worth the trouble.

Mr. Shoolbred said that in regard to the condition of secondary cells it was stated that a hygrometer gave some solution to the question. He should be glad to know Mr. Drake's experience in this direction.

Mr. Drake was understood to say that the available space in the cell was of too limited a nature. The hygrometer required to be floated, and

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this would entail an increased bulk of acid. Such, at all events, was his opinion.

Mr. SHOOLBRED: Then you are not practically acquainted with this question?

Mr. DRAKE: No, not practically.

Mr. SHOOLBRED then remarked that to the best of his belief Mr. Preece had obtained some gratifying results with the hygrometer in testing the condition of secondary batteries.

Mr. MORDEY then described an automatic regulator for maintaining a constant current in an electric light circuit. As to the secondary generators, he would ask Prof. Forbes if there was any advantage in using them in parallel circuits. Another point upon which he was not quite clear was the actual loss of energy in the core due to the rapid magnetisation and demagnetisation. There must be great difficulty in eliminating the effect of molecular action. In ordinary dynamos, where reversals of polarity were not very rapid, this difficulty was not felt, but in secondary generators, where the reversals amounted to several thousands per minute, it would seem possible to measure the loss of which he spoke.

M. GAULARD said that the loss consumed a small portion of the total energy, but had no mischievous effect whatever.

The CHAIRMAN said that as a matter of fact the electric light industry was not rushing on so fast as they could wish, but it must be remembered that two or three years ago they were in absolute danger. False steps were made, and now some of those who had been foremost in the movement had gone. Prof. Forbes, in his Cantor Lectures and in his paper that night, had shown them the results of much care and thought. They might now be said to be in a more stable position as regards this matter than they had ever been before. When with storage batteries they could get 70 or 80 per cent., it became evident that great progress had been made in the construction of this apparatus. In regard to secondary generators, he thought that the successful experiment made by Sir Coutts Lindsay and the experiment made some time ago by MM. Gaulard and Gibbs in the lighting of the Edgware-road Station and a portion of the Notting Hill-gate District were also evidence of progress. The system was a good one then, and it was now a better one by far.

Prof. FORBES, replying to the questions which had been raised, said that there was but little left for him to answer. Mr. Kapp had pointed out the importance of decreasing the speed of dynamos. He congratulated Mr. Kapp upon decreasing the speed of his dynamos, but he congratulated him still more upon increasing the magnetising induction. There were, it was true, fewer chances of a breakdown with his machine; but at what a cost had this been bought? It was a grand machine, weakened by slow speed—a giant crippled. For central stations its slow speed was advisable, and the only way to get a proper effect was by increasing the size. In regard to Mr. Drake's remark on secondary batteries, he thought it would be a serious drawback if they could not be made without attendance. Mr. Drake had suggested the idea of the master cells to him (Prof. Forbes). Mr. Mordey had asked what advantage could accrue from using secondary generators. There was this advantage, that with the primary circuit in series and the secondary circuit with the discs in parallel it was possible to have a current of something like 10,000 volts in the primary circuit and 100 volts in the secondary circuit. Any desired variation could be made. The loss of energy in magnetisation and demagnetisation was, as M. Gibbs had told them, an extremely minute quantity, and when iron wire was used could not be detected.

The usual vote of thanks concluded the proceedings.

LEGAL.

The United Telephone Company v. Bassano and Slater.

In the Court of Appeal on Wednesday, before Lords Justices Cotton, Bowen, and Fry, an application was made by the plaintiffs in this action to dismiss for want of prosecution an appeal presented by the defendants from the judgment of Mr. Justice North, on August 12 last, restraining the defendants from infringing the plaintiffs' patent of July 30, 1877, for the Edison transmitter for telephones. The trial of the action, on the 13th of July last, was reported in *The Electrician*. On the 12th of August Mr. Justice North gave judgment as above stated, and also ordered the defendants to deliver up certain instruments which were in their possession. The learned judge, however, postponed stating his reasons for his judgment, and he has not yet stated them. On September 23 last the defendants served notice of appeal. On December 4 a receiving order in bankruptcy was made against the defendants on their own petition, and in consequence of this the appeal could not be brought on in its proper turn. The plaintiffs on the 19th inst. gave notice of motion that the appeal might be dismissed for want of prosecution.

Mr. ASTON, Q.C., and Mr. MICKLEM, for the plaintiffs, now moved accordingly.

Mr. CLAUDE PLUMPTRE, for the bankrupts and the official receiver, urged that until the learned judge had stated his reasons for his judgment it was impossible for the official receiver or the bankrupts to be properly advised as to the prosecution of the appeal. The official receiver would have a *locus standi* by reason of the order for the delivery up of the instruments.

Mr. ASTON replied.

Lord Justice COTTON said that the application was of a somewhat novel character. If the official receiver was carrying on the business of the bankrupts he would be interested in the injunction. And, notwithstanding the bankruptcy, the bankrupts were also interested in it, because it prevented them from carrying on their business by the work of their own hands, and if they committed a breach of it they would be liable to be sent to prison. The Court had ascertained from Mr. Justice North that he would state his reasons within a short time, and they thought that the proper order to make would be this—that if the bankrupts did not within a fortnight after Mr. Justice North had stated his reasons give security to the amount of £100 for the costs of the appeal, or the official receiver did not within the same time make himself a party to the action, the appeal should, without any further order, be dismissed without costs. If within the fortnight the bankrupts should give the security, but the official receiver should not make himself a party, the appeal would proceed as that of the bankrupts alone. On the other hand, if within the fortnight the official receiver should make himself a party, but the bankrupts should not give the security, the appeal would proceed as that of the official receiver alone.

COMPANIES' MEETINGS.

The Maxim-Weston Electric Company (Limited).

The fifth annual ordinary general meeting of the shareholders of this Company was held on the 19th inst. at the City Terminus Hotel, Cannon-street, Mr. Hugh Watt, M.P., presiding.

Mr. JOHN WRIGHT (the acting secretary) read the notice convening the meeting, and the report of the Directors and statement of accounts were taken as read.

The CHAIRMAN said it was now a year since he had had the pleasure of addressing the shareholders in general meeting. Since then they had found it necessary to meet on two separate occasions, and he thought he need not refer to the object of those meetings beyond stating the fact that immediately afterwards they secured the sanction of the Court to the resolutions which had then been submitted, passed, and confirmed by the shareholders. They secured that without the necessity of adding the word "reduced" to the title of the Company, as was sometimes insisted on. On the last occasion, just a year ago, when he addressed them, he ventured to enter *in extenso* into the past history of the Company. At present he did not think it necessary or desirable that he should do so. He trusted that as long as they held the position they now did they would learn what lessons they could from the past, and endeavour to utilise them for the advantage of the Company in the future, and he did not believe it would be either wholesome or desirable to go just now into the early and unfortunate history of the Company. He did not think he need say that the financial position of the Company to day was stronger than it had ever been. The cash reserve at the bankers and on deposit was sufficient to prove the fact, and, in view of their improved condition, he thought the Directors were warranted in submitting a recommendation as to the payment of a dividend. He ventured at an extraordinary meeting, after the business for which the meeting was convened—the only business which could legally be transacted at that meeting—had been closed, to submit a short statement as to the position of the Company, the contracts which had been carried out or were in progress—a short *résumé* of their proceedings, in fact, up to that date. This naturally left him very little to say to-day. The proposal that a suggestion should be made from the other side of the table with regard to the amount of dividend which they were entitled to, and ought to pay, led to the Board making the recommendation which they would do, namely, to pay a dividend of 7½ per cent. upon the present amount of capital. As he supposed he might assume that most of the hon. proprietors whom he had the pleasure of addressing were business men, it was quite unnecessary for him to go into the general question of trade depression. They were all, he was afraid, only too familiar with that subject. It must, therefore, he thought, be to some extent gratifying to the shareholders of the Company that, passing through such a crucial period as they had done last year, the Directors were able to come before them with a substantial profit, after paying all legitimate and working expenses. In connection with another company he saw the other day that a noble lord ventured to state what must be encouraging to all investors in electric lighting enterprises—namely, the fact that electric lighting generally was improving. He (the speaker) had much pleasure in endorsing this opinion. It was not only improving, but they had inquiries from all parts of the world for installations. They had orders from nearly every colony, and had found them a more lucrative field than the home markets, containing, as they did, such a plethora of dynamos and other plant of almost every manufacture. The directors had, therefore, occupied their attention during the past year to a large extent with colonial and foreign trade, and during the last two months had made several of the largest shipments of electric lighting plant upon order that had ever been made, he supposed, from this or almost any country. During the last twelve months he was happy to say that, though their books did not show a largely increased value of plant sold to that of the previous year, they turned out in weight—that was in machines, lamps, &c.—a very much larger amount than in the preceding twelve months. The reduced sale price of the plant was owing to the amount of competition to which they had been subjected. Last year, in speaking to them he ventured to express the hope that they might be able to secure continued good prices and a larger volume of business. This, however, did not turn out to be quite the case, and he had no hesitation in confessing that the position of the Company to-day, and the amount of business they had been able to transact, were not up to his expectations. He did not know at that time that other companies who were on the verge of liquidation, and who had since unfortunately gone into liquidation, had such a large amount of plant on hand, the result being that of course the liquidators of those companies in winding up their affairs had to submit to auction an enormous amount of material. That naturally depressed very much the enterprise for the past year. At the same time he had pleasure in stating with regard to the patents held by this Company to date, they were still in the forefront, and he did not think any better lamp had yet been discovered, although they had from day to

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day and from month to month been kept upon the tenterhooks of expectation of something coming out which would entirely eclipse the Maxim-Weston. So far, nothing of the kind had happened. They had continually gone on experimenting with, and improving upon, their patents, and partly with a view to that they were on the eve of taking a larger factory, where they would be able to manufacture not only what they were at present doing, their own dynamos, but all the plant of the Company, excepting only incandescent lamps. With regard to these he had concluded such an arrangement with the American Company as would meet their requirements, for he did not think it would be possible for them to go to the expense of laying down special plant for incandescent lighting, and the carrying of it out for the same price to which he had been able to squeeze down the American Company. He might also say, as he had referred to the present company in America, that so far that company had met them very fairly. The only difficulty they experienced during the last few months had been the inability of the American Company to supply them with sufficient despatch with the plant that had been required. This was owing entirely to the enormous development of the business in the United States of America, where there were £2,000,000 or £3,000,000 profitably employed in the manufactures and in the installations of sub-companies of the American Company throughout the Union. This he thought was a sufficient guarantee that their plant was all that it was promised to be when the present Directors took it over, subject to such improvements as they had made. During the present year he hoped they would be able to considerably improve their arc lamp plant. Their efforts hitherto had been mainly directed to endeavour, by means of experiments, to secure better results—that was to say, to enable them, through the same dynamo, to run a larger percentage of lamps, which of course proportionately cheapened the machine. In that way they had been able to a great extent to maintain the price of their various machines by securing, through winding and otherwise better results in the number of lamps. He hoped during this year they would be able, by undertaking the manufacture of this plant, to save something like 20 to 30 per cent. upon the present cost price of machines to them. This was a very material matter, because during the last two months he had been negotiating with almost every country in Europe, over and above the colonies, with the view of increasing their business. The result of those negotiations in a great many cases had been to prove that the prices charged them by the American Company virtually put them out of the market in competing with rivals on the Continent. He was in hopes, by means of larger premises and the improved results which he thought they would obtain within the next three months in connection with the arc lamp, to be able to compete at a good profit with their Continental opponents, whose material was cheaper, whose iron and labour were cheaper, and whose expenses in connection with manufacture were not nearly so high as they were in England. If they could manage to compete in countries like Germany it was all, he thought, they could hope to attain with regard to the cost price of their plant. He might mention that they had not secured the premises referred to in the report, but after a great deal of trouble and inquiry on their part they hoped to save about £200 a year in the rental of the premises they were trying to acquire, and which would afford accommodation to the extent of 8,000 or 10,000 cubic feet. Their system, he was happy to say, was growing in favour, and the Maxim-Weston installation had given the greatest satisfaction. The last installation completed had been in connection with the Post Office. He was gratified to say that, after numerous experiments, first of all directed to secure a non-flickering light by means of a gas engine, they had succeeded—he thought he might say, in all humility, the first time in the history of electric lighting companies. Their next object was, by a subdivision of the light, to obtain the greatest and most varied results at the lowest cost, for this really, after all said and done, was the great desideratum in regard to electric lighting which they were all hoping to attain in their competition with the greater power, gas. In connection with the Post Office department and the savings' bank department, they had to contend with the difficulty of switching on and off from one room to another, and if they managed this in the case of 36 different circuits from the same machine, they would effect an economy varying from 30 up to 60 per cent. They had no data to go upon; but had simply to wrack their own brains, and find out, by means of a switch-board, what would answer all purposes to arrange from three machines a switch of 36 circuits. With the manager of the works, who was a man second to none in his profession, after some two months' time they had designed a switch-board, which the officials of the Post Office, including one of the best known electricians of the day, Mr. W. H. Preece, told him was entirely successful. They were met by the chief men connected with the postal department to investigate this installation. It was the first run, and, of course, the first run was not often the best, but Mr. Tough was so satisfied with the switch-board that they allowed the officials to be present at the test trial. The result was entirely successful, and after two or three hours' running the Post Office authorities were pleased to express their entire satisfaction with, and to pass the installation. He might mention that they had entered into an agreement with the Post Office to run it for two years at a very handsome rental, thereby in a great measure guaranteeing the efficiency and the durability of their plant, a point they naturally set a good deal upon with regard to the future.

A SHAREHOLDER: Are they incandescent?

The CHAIRMAN said that the installation was incandescent. There were at present 700 lamps running. They found that with the engines they used, three 40 horse-power Ottos—the largest gas engines in use—their machines required very much less power than those of any other system. They discovered, for instance, that two machines could be driven by the same engine, and would give them a maximum of 500 lamps. Consequently, the postal authorities, as soon as the details of the installation had been completed, intended, he thought he might say it in all confidence, to duplicate the installation. The only difficulty at present was with regard to a tenant whom the Post Office had arranged to buy out, and thus increase their basement accommodation. When that was done he believed he might safely say that the Post Office would give them a duplicate contract. That installation was the largest they had ever undertaken, and after the success which had attended it, in enabling them to switch off from thirty-six different rooms on to any of three machines, they were prepared to say that they could carry out lighting of the most varied character. They had done their best in the matter of increasing their agents, some of whom had got for the Company a considerable amount of business during the last few months. Whether it was from the fact that the repute of the Company was going up he did not know, but they had had applications from the first electrical agents throughout England and Scotland, with the object of representing the Company in their districts. Hitherto agents had been very much disposed to want all the profit to themselves. He had no objection to give an agent a fair commission, but he objected to allow to him the entire profit in view of the fact that this Company had expended about £140,000 in connection with their patents. He would now shortly review the report and balance-sheet, which he might mention he and his colleagues had endeavoured to draw up in as lucid a form as they could. The first paragraph referred to the fact that during the last two years no sum had been laid aside for bad and doubtful debts and other contingencies such as were referred to in Clause 75 of the Articles of Association. He wished to refer to this specifically, inasmuch as the Directors did not wish to utilise the fund they now had for any purpose unknown to the shareholders, and he might mention that in taking larger premises they would have to spend a good amount in putting up new fixtures and so on, which came within the meaning of the clause referred to. The Directors therefore decided to set aside the sum of £3,606 to the credit of a general reserve fund. As far as the present Board was concerned he was happy to say that during the last two years and nine months he did not think they had contracted £600 worth of bad debts. This, he thought, said something for the Board, because it was one thing to sell plant and quite another to get the money for it. They could have done a much larger business had they been content to take a certain number of risks which would have hardly been judicious with the comparatively circumscribed funds at the disposal of the Company. After setting aside the sum mentioned to reserve, the total balance at the credit of profit and loss account amounted to £5,284. At the last meeting the shareholders thought it proper to veto a proposal of his—which he made in perfect good faith—to declare a dividend. He had now no wish to dispute the wisdom of that decision; but to-day it enabled the Directors to recommend a dividend so much in excess of what it would have been in their power to do if they had not carried forward so large a balance last year. The Company was now in a position not only to warrant but to entitle them to pay a dividend, as the Directors proposed, of 7½ per cent. Of course the recommendation was entirely amenable to the decision of the shareholders, inasmuch as the payment and the amount of a dividend rested entirely with them. He need not dwell upon the next clause of the report, which referred to their having obtained the sanction of the Court to the reduction of capital, by which patents' account had been reduced to £35,000, which included outlays during the past year in connection with the new patents. The plant and machinery at the factory had been valued by himself, with the assistance of the work's manager, and he could vouch for the fact that it was all new, and in good saleable condition. Owing to the growth and requirements of the business, as he had said, they were looking out for larger premises, which would effect a saving of two or three thousand pounds to the Company in the event of their having to turn out a greater number of machines than they had done during the current year. They had encountered very great difficulties in connection with some of their staff. The electricians, however, were men who, he was happy to say, had been with the Company since he took the management of it, and they continued to give great satisfaction, and were, he believed, contented with their position. The *employés* were also of the opinion, he might say, that the Maxim-Weston patents were about the best in the market, and that the Company must in time attain a leading position. They had done considerably more business last year, although the profits were not much in excess of what they were a year before, owing to their having had to reduce their prices rather than lose orders from customers from whom the money was sure. As soon as the present Government got fairly settled down to business, and the perpetual question of Ireland was disposed of, he hoped to be able to induce the President of the Board of Trade to consider some suggestions which he (the speaker) hoped to have the pleasure of submitting to that gentleman. He did not quite anticipate, as did the chairman of another company, that electric lighting would immediately employ thousands of workpeople in this country, or that the profits from it would amount to millions of money. As a business man, he could not see how companies at present doing a small business relatively to the enormous capital invested by the public in connection with the electric lighting enterprise could all of a sudden be inflated like balloons and begin to make millions of money. He anticipated no such result. He had never been a pessimist, but he did not like to indulge in too glowing an account of the future of the electric light. It was like that of all other enterprises, uncertain; but, as far as they could see at present, the future of this Company might be assumed to bring to them a gradual development of business and steadily improved dividends. He did not think he had much to add with regard to the balance-sheet. The first item he had already explained. The second item—"machinery and stock at factory £12,285"—was put at a sum considerably under the sale price of to-day. The shares in the Electric Sun Lamp and Power Company (Limited) would, he believed, realise about the sum named. With regard to debtors, as he had explained at previous meetings, over a third of the amount was due by the British and Colonial Governments, and as

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for the remainder, as far as they could make out, they were entitled to assume that it would be all realised. He had no anxiety with regard to the item. Cash at bankers and on deposit required no comment. Coming to profit and loss account, the expenses for the year amounted *in toto* to £3,630. Last year they stood at about £1,300 less. The excess had been mainly owing to an increase in their staff, and to travelling expenses, which had been somewhat heavy in consequence of their going about opening up new fields of enterprise, which he trusted would be valuable for the future, and the other ordinary charges. The amount to be carried forward, after the payment of the dividend, would be about £600. He concluded by formally moving the adoption of the report and accounts.

Mr. LOUIS SWABY said he had much pleasure in seconding the motion. Some three years ago, when the present Directors took over the management of the Company, they had no idea of the difficulties that they had to contend against. Even if they had failed to bring the Company to a successful position he would have considered it no disgrace; but he was happy to say that they had not failed, and he fully believed that the future of the enterprise was an exceedingly bright one. He was pleased to say that one of those difficulties was gradually passing away—he wished he could say that it had disappeared altogether—he referred to what he might call unfair competition. They had sometimes to allow contracts to go past them which other people were found willing to execute at a loss, but which this Company would not undertake except at a reasonable profit. He believed such work was called "exhibition work"—in other words, work done for the sake of advertisement. If this Company had gone in for exhibition work they must have very soon gone into liquidation, and from what he read in the newspapers he thought that other companies were coming to the conclusion that to do business for such a purpose was not a paying game. He did not think it would be right for him to sit down without giving credit where it was due, and he was sure his colleague, Mr. Brown, would bear him out in what he was about to say, by frankly stating that the success of the Maxim-Weston Company was wholly due to the efforts of the Chairman, who had had no light work in bringing the Company to its present position.

Mr. GRIFFITH asked if there had been or was to be any fresh issue of shares. If so, he thought that the present shareholders, who had stood by the Company so long, ought to have the first refusal of the new issue.

Mr. JACKSON wished to know whether it was necessary according to the Articles of Association to add annually something to the reserve fund?

A SHAREHOLDER suggested that it might be advisable in the interests of the Company to establish their works a little way out of London, where premises and labour might be obtained considerably cheaper than in the metropolis.

Another SHAREHOLDER drew attention to the large item which figured in the accounts as claims upon debtors, and desired to know whether any of the sum had been paid off. He thought that more details should be given as to the expenditure.

The CHAIRMAN, in reply, said that if it were the wish of the shareholders that a more detailed statement should be given, the Board would be only too happy to accede to the request in future. He did not wish to draw any analogy between the expenses of this and other companies, but it did not seem to him that the amount which had been spent in the conduct of so extensive a business, involving the payment of some thirty or forty workpeople, was a very large one. As to the debtors, he thought he had explained that the Company's business was transacted all over the world, and they must therefore perceive that in was impossible to receive from and execute orders for distant places without incurring a delay of at least six months in many cases before they could receive the money for them. He was happy, however, to say that they had received a considerable sum since the end of last year, and he hoped that before a month was passed to receive £3,000 more. Of course, in connection with Government contracts, they must be all aware that supplies were voted only once a year, so that he did not think that any Government contract could be undertaken without their having to wait nine or ten months before they received the money for it. He had the assurance of the chief officials of the Post Office that the Company would be paid, on account of the installation in connection with that department, over £2,000, being the balance remaining due to the Company, within three or four weeks. With regard to increased capital, he was happy to be able to inform the hon. proprietor that there had been no fresh issue. The Directors had no power to make one. A resolution passed on the 16th of May, 1884, was to the effect that no further issue of shares, beyond the 250,000 shares, could be made without the sanction of a resolution of the shareholders passed at a general meeting of the Company duly convened for the purpose. The present meeting, therefore, could not deal with the question even if it were raised, and certainly the Board could not deal with it. He was much obliged to the gentleman for the suggestion that they might, with profit to themselves, establish their works out of London. But he (the Chairman) thought that his own proposal to get new and cheaper premises in London was a better one. The Directors had duly considered the subject, and they had come to the conclusion that if they could secure the works for which they were now in treaty they could not do better in the interests of the Company. As to the wages of their *employés*, he thought they would compare favourably with those of any workpeople connected with any mechanical enterprise in the kingdom. The books of the Company were open to every shareholder. The Board had nothing to conceal, and if any of them would ask for information he would be at all times ready to furnish it. The reserve fund had been set aside purely for the objects he had named. There was nothing binding in the articles with regard to reserves. He knew very well that such a fund made a company sound very well for stock-broking purposes, of which he personally knew nothing. At the same time the Directors saw their way to declare what he ventured to think was a substantial dividend, and to reserve something to meet the contingent charges to which he had referred. He regarded it, moreover, as a prudent step to lay aside money in the event of their not being able to pay next year the same dividend that they did now. He personally believed, however, that they would be in a position to divide a much larger sum, which shareholders like himself in a Company which had been unfortunate at first and unfortunate in its procedure for more than a year, until the present Board took office, had a right to expect. He concluded by putting the motion, which was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. BROWN, the dividend recommended by the Board of 7½ per cent. was declared.

The retiring Directors, Messrs. Watt and Swaby, were afterwards re-elected on the motion of Mr. GRIFFITH, seconded by Mr. JACKSON.

A resolution, proposed by Mr. GRAY and seconded by Mr. HILLIARD, fixing the remuneration of the Directors at £500, was subsequently passed, as was also a vote of thanks to the Chairman, which terminated the proceedings.

Swan United Electric Light Company (Limited).

The adjourned general meeting of the shareholders of this Company was held at the Cannon-street Hotel on the 23rd inst., under the presidency of Mr. F. R. Leyland.

The SECRETARY (Major S. Flood Page) read the notice convening the meeting, which intimated that it would be necessary to adjourn again.

The CHAIRMAN said he was sorry, in the unavoidable absence of the Chairman of the Company, to have to move a resolution for further adjourning the meeting. The negotiations which they had been having with the foreign companies were not yet settled, and, therefore, they thought it would be injudicious to hold their general meeting at present. They thought that the negotiations should first be settled either one way or the other. It was for that purpose that they proposed that the meeting for the consideration of the accounts and other matters should stand over until the 23rd of March. He concluded by moving a resolution to that effect.

Mr. W. C. QUILTER, M.P., in seconding the motion, observed that he did not think it was necessary for him to say anything more to convince the shareholders of the advisability of not having any discussion on the affairs of the Company during the continuation of the negotiations referred to, which must be more or less of a delicate character.

The CHAIRMAN put the motion, which was at once carried unanimously, and the proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. Feb. 24.	Business Done Week Ending Feb. 24. Highest.	Lowest.
Anglo-American	33½, 34½	34	33
Do. Preferred	56½, 57½	57	55¾
Do. Deferred	10½, 11½	11¼	11
Brazilian Submarine	10⅞, 11⅛	11 1-16	10⅞
Cuba	10¼, 10¾	—	—
Do. Preference	17, 18	—	—
Direct Spanish	1½, 2	—	—
Do. Preference	11½ 12	12	11 15-16
Direct United States Cable	9⅜, 9⅝	9 7-16	9⅜
Eastern Telegraph	11⅞, 12⅛	12⅛	11 13-16
Do. 6 per Cent. Preference	13⅞, 14⅛	14¼	13¾
Do. 5 per Cent. Debentures, 1899	104, 107	—	—
Eastern Extension	12⅞, 13⅛	13⅛	13
German Union	9½, 10	9⅜	—
Globe Telegraph and Trust	6⅞, 7⅛	7 1-16	6⅞
Do. Preference	13⅜, 13⅝	13⅝	13⅜
Great Northern	14½, 15	14⅜	—
Indo-European	84½, 85½	35½	34¾
Reuter's	6¾, 7¼	6⅞	—
Submarine	205, 215	212½	210
West India and Panama	¾, 1	¾	—
Do. 1st Preference	8¾, 9¼	9⅛	8 15-16
Western Brazilian	6⅝, 6⅞	6 13-16	6¾
Western Union 7 per Cent. 1st Mortgage	117, 121	—	—
Do. 6 per Cent. Sterling Bonds	100, 104	—	—

TELEPHONES.

Companies.	Closing Prices. Feb. 24.	Highest.	Lowest.
Consolid. Telepho e and Maintenance	15-16, 1 1-16	—	—
Oriental	3-16, 5-16	—	—
United Telephone	12¼, 12¾	12 7-16	12¼

ELECTRIC LIGHT.

Companies.	Closing Prices. Feb. 24.	Highest.	Lowest.
Anglo-American Brush Light (£7 paid)	3⅛, 3⅜	3 7-16	3 5-16
Do. (fully paid)	5, 5½	5⅝	5¼
Hammond Light (£3 15s. paid)	1-16, 3-16	—	—
Swan	1½, 1¾	1¾	1⅝
Maxim-Weston	5-16, 7-16	⅜	—

MISCELLANEOUS.

Companies.	Closing Prices. Feb. 24.	Highest.	Lowest.
Telegraph Construction	38, 39	39	38½
India Rubber, Gutta Percha, and Telegraph Works	23½, 24½	24½	24⅛

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NOTES.

APPROPRIATE.—A suggested word for "telegraphic address" is "telenym."

BOOKS RECEIVED.—"Manuale Teorico-Pratico dell' Elettricista," by P. Meardi, and others, Milan. The *Elettricita* Press.

THE TELEGRAPH IN SENEGAL.—According to *L'Akhbar* the telegraph line between Bakel and Matam is practically finished.

TOWN LIGHTING.—An installation of the electric light is now being put down in Salon, a small town in the department of the Bouches-du-Rhone.

THE ELECTRIC LIGHT IN BOSTON, U.S.A.—The mechanical engineering laboratory of the Institute of Technology is now lighted by incandescent lamps.

THE TELEGRAPH BATTALION.—A detachment of the Telegraph Battalion of Royal Engineers has been placed under orders for proceeding to Egypt.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of February, amounted to £48,814, against £61,784 in the corresponding period of 1885.

THE TELEPHONE IN BELGIUM.—The adjudication of the concession for the establishment and exploitation of the telephone system in the town of Malines has been postponed until the 31st inst.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of February amounted to £1,576, against £1,442 in the corresponding period of last year.

THE VAN RYSSELBERGHE SYSTEM.—It is reported that the Administration of Telegraphs in Switzerland have decided to adopt the Van Rysselberghe system of telephony on the line between Bâle and Zurich.

THE TELEPHONE IN BRISBANE.—The rapid increase in the number of telephones required throughout Brisbane has caused the Government to introduce the system of aërial cables patented by Siemens Brothers.

NEW SOUTH WALES MINISTRY.—The Agent-General for New South Wales has received a telegram from Sydney informing him of the formation of a new Ministry. The Hon. F. B. Suttor is the new Postmaster-General.

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of February amounted to £33,688, and to £40,114 in the corresponding period of 1885.

THE TELEGRAPH IN SOUTH AFRICA.—The use of the telegraph for the remittance of money is rapidly spreading. In 1884, 3,050 orders were issued for £18,139; in 1885, the number was 6,713, and the amount £40,182.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended Feb. 26, were £2,662, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

LONG DISTANCE TELEPHONY.—The experiments recently carried out with the Maiche apparatus between Paris and Troyes, a distance of about ninety-nine miles, are said to have yielded very satisfactory results. The trials will be repeated at an early date.

NEW PERIODICAL.—We have received the first number of a new monthly periodical called "Worthy Workers." It is at present on rather a small scale, but as the subject suggested by the title is a somewhat extensive one, we may hope to see this remedied later on.

TASMANIA.—The following are the submarine cable receipts for December:—Paid in Tasmania, £438, 13s. 5d.; paid elsewhere, £331. 4s. 4d.; total, £769. 17s. 9d. The number of messages during that time was 5,048, being the largest number yet despatched in a month.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended 28th Feb. are £2,483, as compared with £2,515 in the corresponding period of 1885. The November receipts, estimated at £3,935, realised £3,996.

A NEW LABORATORY OF PHYSICS.—The old Tour St. Jacques la Boucherie, Paris, celebrated in connection with Pascal's experiments on atmospheric pressure, is now the site of a Laboratory of Physics. The inauguration took place on January 13. The tower was lighted by incandescent lamps.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of February was 3,402, estimated to produce £2,750, against 3,225 messages, producing £2,730, in the corresponding month of last year. The traffic receipts for the month of November, estimated at £2,250, realised £2,313.

THE ELECTRIC BLASTING COMPANY.—We are informed that this company has just successfully started a set of apparatus of G. B. Walker, Esq., at Wharncliffe Silkstone Colliery, near Barnsley, and has received an order for four sets of apparatus for blasting all shots fired in Harris' Navigation Colliery, Treharris, one of the largest collieries in Wales.

THE ELECTRIC LIGHT FOR WARSHIPS.—The "Collingwood" has been fitted with the electric light on the principle carried out on the "Impérieuse." She has no less than 420 lamps, the largest number of any ship in the service; and as the trials on board the "Impérieuse" proved so satisfactory, the trial of the lighting of the "Collingwood" is to be proceeded with forthwith.

POST OFFICE TELEGRAMS.—In the House of Commons on Monday night, Mr. H. H. Fowler, replying to Mr. E. D. Gray, said there was no regulation to the effect that when a telegram was sent from a local post-office to an address in the same town the name of the town should be inserted. At Belfast and Cork this insertion had been insisted upon, but instructions to the contrary had been given.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—A meeting of this society will be held at the Institution of Civil Engineers, 25, Great George-street, S.W., on Thursday, the 11th inst., at 8 p.m., when the following papers will be read:—"Economy in Electrical Conductors," "Note on Magnetic Resistance," by Profs. W. E. Ayrton, F.R.S., and John Perry, F.R.S., members.

SIR H. D. WOLFF'S MISSION.—In the House of Commons last week Mr. Bradlaugh asked the Under-Secretary of State for Foreign Affairs to state the total amount of actual payments for telegrams to and from Sir H. D. Wolff, distinguishing those to and from Turkey and to and from Egypt. Mr. Bryce said the total cost of telegrams sent to Sir. H. D. Wolff was £772, and of telegrams received from him £3,192.

THE ELECTRIC LIGHT IN MANCHESTER.—The lamps, &c., at the new offices of the Lancashire and Yorkshire Railway Company, Manchester, are 1,300 in number, supplied from 4 shunt normal Wolverhampton dynamos. A set of accumulators is also provided to keep 120 lamps alight for three hours after engines are stopped, or for a greater length of time if

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necessary. The lamps, we believe, are Woodhouse and Rawson's.

THE ELECTRIC LIGHT AND THE HOUSE OF LORDS.—In the House of Lords on Tuesday night Lord Limerick moved that a report of the evidence taken before a Select Committee with reference to the ventilation of the House be laid upon the table and printed. Lord Milltown suggested that the electric light should be introduced, as the machinery used for ventilating could be utilised for the electric light. The motion was agreed to.

TELEPHONE IN FRANCE.—In France, at the end of December, 1884, there were 3,534 subscribers to a telephone system which embraced nearly 4,000 miles of underground wires and about 33 5 miles of overhead wires. At the end of December, 1885, the number of subscribers was 3,983, the underground wires 4,320, while the overhead wires remained practically the same; thus the extension has been, as far as the lines are concerned, in the direction of underground wires.

A NOVEL IDEA.—One of the latest inventions with which America is to be credited is an automatic device for setting up type by electricity. By means of this apparatus and a synchronous telegraph the merry compositor in his hour of luxury or of debility may set up his copy at the office from the sanctitude of his domestic hearthstone. We commend this machine to the notice of foremen printers who yearn for quietude, and " comps. " who suffer from *l'embarras de richesse.*

SOME INTERESTING STATISTICS.—In America the amount of capital sunk in the electric light business is said to amount to 70,000,000 dollars. About 25,000 incandescent and 12,000 arc lamps are installed yearly. In the manufacture of glow lamps over six tons of mercury and 700 air pumps are now in use. The city of New York pays about threepence per hour for each lamp of 2,000 candle-power. To supply the arc lamps in the United States 300,000 carbons are manufactured daily.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—We are informed that the directors of this company declared, on the 3rd inst., an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, free of income-tax, for the quarter ended 31st December, 1885, and payable on the 25th inst. The books of this company will be closed from the 18th to the 24th inst., both days inclusive.—The traffic receipts of this company for the week ended 26th ult. amounted to £3,478.

THE BOISSELOT TELEPHONE. — According to our foreign contemporaries this telephone is characterised by several novel points of construction. The magnet is of charcoal iron, curved in a manner which is said to give great force in a small volume, and actuates a number of coils wound upon small Maiche armatures fixed at the bottom of the metallic case which encloses them. The coils, being independent, are said to possess great mobility and to be susceptible to very exact regulation.

BALL AT THE ELYSEE.—Advices from Paris state that the recent ball at the Elysée was, as usual, very crowded. More than four thousand persons attended. An incident of the evening was a glazier making his way into the State Rooms. He was able to do this because an usher fancied that he was employed to look after the electric fittings for the lamps in the chief ball room. The glazier strolled hither and thither, and then asked to see M. Grévy, with whom he said he had an appointment.

THE ASSOCIATED CHAMBERS OF COMMERCE AND THE TELEPHONE.—At the twenty-sixth annual meeting of these Chambers, held recently, the following resolution, proposed by the Hull Chamber, was passed:—"That in re-affirming the resolution of last year, the Executive Council appoint a deputation to wait upon the Postmaster-General to urge the necessity of a material reduction in the rental charges of telephonic instruments supplied to various towns in the United Kingdom."

MIDDLETON-IN-TEESDALE.—It is said a gentleman in this district has devised a method whereby the greater part of the valley of the Tees could be illuminated by means of the electric light. He proposes to utilise the High Force and the Caldron Snout for the requisite power, the vast water-pressure there, in his opinion, being at present totally wasted. The machinery to be erected at the waterfalls in question would be of such a character as not to disfigure the scenery. His plans and drawings are nearly completed, and, when ready, will be submitted to the public.

TELEGRAMS TO THE ROYAL COURTS OF JUSTICE.—The superintendent has issued the following notice respecting the transmission of telegrams to the Royal Courts of Justice, viz.:—Telegrams will be issued direct to the office No. 605 in the Royal Courts of Justice, and will be delivered therefrom by a messenger into the rooms indicated. The surname, number of room, and "Courts Justice" will be the recognised address for all town messages, "London" being added if sent from a country district. No title, initials, or christian name will be necessary, except only the latter where two officers of the same name occupy one room.

THE PICCADILLY RESTAURANT.—By the opening of the new Piccadilly Restaurant, an addition has been made to the already large number of sumptuous houses of entertainment at the West-end of the town. The building is situated upon the broad new open space at the beginning of the new thoroughfare from the eastern end of Piccadilly to New Oxford-street, and is at the south-west angle of the large block of solid masonry of which the new Pavilion Music Hall forms an important portion. The decorations are in the Italian style, and the whole building is lighted by the beautiful little glow lamps or incandescent electric lights.

TABLE LAMPS.—The Woodhouse and Rawson Electric Supply Company write to inform us that they have introduced an inexpensive, but artistic, table lamp. This is designed to meet the requirements of those who wish to use incandescent electric lamps for studies, lecture tables, &c., or for exhibiting and explaining the nature of the electric light without having to incur the expense attached to ordinary installations. They are made in three different styles, either polished or nickelled, brass and green bronze. A neatly designed switch is placed in a position similar to that occupied by the regulator of an oil lamp. Two terminals are placed in the base of the lamp, so that the connections, which can be readily made, are not obtrusive.

ROYAL INSTITUTION.—At the general monthly meeting of the members held on Monday last, Mr. Warren de la Rue, D.C.L, F.R.S., vice-president, in the chair, Sir U. Kay-Shuttleworth, Bart., M.P.; Sir W. Thomson, F.R.S.; Dr. John Abercrombie, Messrs. W. H. Barlow, A. Carpmael, H. Doetsch, J. P. Fearfield, R. Gent-Davis, M.P.; J. Hopkinson, F.R.S.; J. Inglis, G. Palmer, S. P. Thompson, and W. Tomlinson, Major E. Cecil Johnson, Mrs. T. C. Leitch, and Mrs. S. S. Joshua, were elected members, and seven candidates for membership were proposed for election. The following alteration in the lecture arrangements was also announced:—Prof. Dewar, F.R.S., four lectures on Electro-Chemistry, in place of Prof. Tyndall, F.R.S., on Light.

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ELECTRIC LIGHTING.—In the House of Lords on Tuesday night a Bill to amend the Electric Lighting Act was introduced by Lord Rayleigh, and read a first time.—In the House of Commons on the same night, in reply to Mr. Northcote, Mr. Mundella said:—"I am not prepared at this moment to state exactly what course will be taken with the one Bill and two provisional orders which this session seek authority, among other things, to amend the Electric Lighting Act, 1882. I may say, however, that the Government could not permit any amendment of the general law to be effected by means of a private Bill or a provisional order. The whole question is under the consideration of the Government, and will, if possible, be dealt with during the present session."

THE TELEGRAPH AT SCOTLAND-YARD.—In an article on Scotland-yard the *Daily News* says:—In addition to the communications regularly kept up by documents and printed sheets passing to and fro between each superintendent's office and Scotland-yard, the telegraph of course plays an important part in the keeping of all corners of the great system in touch with each other. Every policeman who rises above the rank of a constable is required to become a practical telegraphist, able to communicate through the Wheatstone instrument with Scotland-yard—where there is quite a considerable telegraph office—from any divisional or subdivisional station. Either by the telegraph or by telephone this executive department of Scotland-yard is also in communication with all the principal public buildings and establishments throughout London.

THE USE OF THE TELEPHONE.—At a recent meeting of the Manchester Board of Guardians, information was telephoned from the workhouse that the labourers on the farm were marching in a body, 150 strong, to the guardians' meeting. Police were summoned by telephone from the Town Hall, and when the labourers arrived the authorities were fully prepared for any demonstration. The Board sent out the workhouse governor with an offer to receive a deputation if the others would go away, and this was agreed to. The deputation asked that the men who were in receipt of relief should not be required to be at the farm until ten in the morning, so that they might have an opportunity of looking for employment. This arrangement the Board assented to, and the deputation having rejoined their colleagues and reported the result, the demonstration terminated peaceably.

NEW COMPANY.—The Railway Electric Lighting Company has been formed to acquire and develop the patents and business of the Railway Electrical Contractors, for lighting railway carriages by electricity generated by the momentum of the train, and stored in accumulators. The capital is £130,000, in shares of £5 each, of which 20,000 shares are now offered to the public. Patents have been secured for France, Belgium, Italy, Germany, Austria-Hungary, and the United States. The directorate is a strong one. We should be pleased, however, to be clearer upon the particular manner in which it is proposed to utilise the *momentum* of the train; and it suggests itself to us that as a matter of possibility *motion*, and not momentum, is utilised, and if this is so, it becomes a question as to whether there are not other patents which may claim priority on the face of the prospectus before us.

INTERIOR ARC LIGHTING.—At a concert given by the Blackheath Conservatoire of Music, at the Rink Hall, Blackheath, on the 23rd ult., the room was brilliantly illuminated by two Brockie-Pell arc lamps, which ran without a flicker for four and a-half hours, and gave the utmost satisfaction. The lamps, which were connected up in parallel, were fed by a current of 22 amperes, from a Holmes-Burke battery of 56 cells of the ordinary size, and the same battery, without being recharged, was again used on the following day for four hours at the new Art Club, Blackheath, to supply a current to the above-named lamps at a private concert. We are informed that at a recent trial before an eminent electrical authority, 40 of these cells ran a Brockie-Pell lamp of 2,000 c.-p., taking 12 amperes, for seventeen and a-half hours continuously with a single charge. We believe this to be by far the best result as yet obtained in electric lighting by any primary battery.

EARTHQUAKES.—A report comes from St. John, Antigua, to the effect that on January 20th, several shocks of earthquake were felt. The first at 1:20 lasted a longer time than any, and was sharp, but those at 1:40 and 5:55 were slight. The one at 5:15 was much stronger. It was thought they came from the south-east and travelled to the north-west. On New Year's Eve an earthquake was felt in the central parts of Norway, particularly at Elverum and Löiten, where the houses shook. Another shock was felt in the province of Christiansand, at about 4 a.m. on January 16, followed by vivid flashes of lightning. In several houses the doors sprang open, and furniture, &c., was moved. A girl was thrown out of bed in one place. The barometer was very low at the time, but remained the same as on the previous day.—A slight shock of earthquake was felt at Moorshedabad on the afternoon of February 1st, at 3:20. A simultaneous shock was felt in Calcutta.

THE PATENT OFFICE.—In consequence of the change of Government it has become necessary to consider what steps ought to be taken with regard to the Departmental Committee which was appointed by the late President of the Board of Trade, Mr. Stanhope, to inquire into the present constitution and working of the Patent Office. The committee consisted originally of three members, viz.:—Baron H. D. Worms, M.P. (the then Secretary to the Board of Trade), Sir Farrar Herschell (the now Lord Chancellor), and Lord Crawford and Balcarres, and it has been decided that the most expedient course will now be for the Lord Chancellor, in conjunction with the present President of the Board of Trade, to appoint a new committee. They have accordingly appointed a new committee, which will be presided over by the Lord Chancellor as chairman, and will consist of the following members:—The Lord Chancellor, Lord Crawford and Balcarres, Baron H. de Worms, M.P., Sir B. Samulson, Bart, M.P., Sir R. E. Webster, Q.C., M.P., and Mr. C. T. D. Acland, M.P.

THE ELECTRIC LIGHT FOR HOSPITALS.—At the last meeting of the St. Saviour's Board of Guardians a report was received from the Building Committee stating that, after carefully considering the tabulated statement of tenders that had been received for lighting the infirmary at Champion-hill with electric light, and conferring with Mr. Jarvis, the architect, on the probable cost of lighting that establishment with gas, resolved that the tenders for electric lighting be no further considered, and recommended that Messrs. Jarvis and Son should be instructed to prepare specifications and drawings for the laying down and fixing of all the appliances and fittings required for lighting the new infirmary with gas. The Chairman said the majority of the committee were of opinion that they should have gas to begin with. If in the course of a few years the electric light was perfected it might be introduced with perhaps good effect. Mr. Cooksey maintained that the the electric light was an unqualified success, and urged its use on sanitary grounds. After some discussion the report was adopted.

THE TELEGRAPH CABLE AS AN ANTI-MONOPOLIST.—It may not be generally known that the telegraph cables laid in foreign waters and along foreign coasts have brought about in many cases an extraordinary change in the trade of the

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localities at which they touch. On the South East African Coast, for instance, a few years ago, one or two mercantile houses held absolute sway, monopolising the whole, or nearly the whole, of the trade; for other and smaller people, Banyans principally, were unable to keep touch of the markets, or to buy on a sufficiently large scale for speculative purposes. But when steamers began to run and cables were laid these gentry began to find out that by the expenditure of a trifling sum they could obtain quotations and forward their orders by telegraph. By watching the local markets carefully and taking advantage of favourable opportunities they competed with and defeated the monopolists. The drastic measures frequently resorted to by local officials, whose interests were dependent upon the continuance of the monopoly, were no longer possible, for Lisbon was within reach, and justice could be obtained within an appreciable time. In the old days delays were endless and remedy practically unattainable.

SCIENCE AND DEMOCRACY.—It is with fee lings of gratification, not unmingled with dismay, that we find our estimate of Sir Henry Sumner Maine's forebodings relating to the future of Science under Democratic institutions, discussed in our leading article of February 19th, entirely borne out by his rejoinder to Mr. Godkin in this month's *Nineteenth Century.* Sir Henry singles out the passage we ourselves had quoted from the American's reply, with the remark that the admissions are "so candid as to leave me in doubt whether the writer seriously dissents from the argument which at first sight he appears to be criticising;" and sums up Mr. Godkin's case as follows: "The gist of all this may fairly be said to be that the American people refuse all submission to intellectual authority, unless it either is, or is seconded by, the authority of persons who have made a fortune in business." After what Mr. Godkin tells us of the relations of science to the multitude in the United States, Sir Henry Maine concludes with a prediction which bodes ill for the future of science: "For the honour of human nature there is one reason why this method of bringing over a sovereign multitude to a scientific opinion will never succeed. The combination of lying, cowardice and hypocrisy which the process of persuasion involves is utterly inconsistent with the possession of the highest intellectual faculties."

HINTS FOR SCOTLAND-YARD.—Mr. Wilfrid King, secretary of the Exchange Telegraph Company, writes to the *St. James's Gazette* as follows:—"Sir: Referring to the articles under the above heading in your issue of Saturday last, I venture to point out that the system of street fire and police signals recommended therein was introduced into this country in 1872 by the Exchange Telegraph Company, and was duly submitted to the fire and police departments. It was adopted by the Metropolitan Board of Works, for the Metropolitan Fire Brigade, in 1877; and has since been of the greatest service in telegraphing calls to fires. It was declined by the Police Commissioners, although we offered to supply signalling post and apparatus at all the 'fixed points' at cost price plus a nominal royalty. The system, with the latest improvements of the company, is neither costly to establish nor maintain; it is not unsightly, and does not require experts to work it. In the case of the Fire Brigade, the lines were erected and are maintained by the Postal Telegraph Department, and the same might be done for the police, so that underground wires may be available. Had this system been so used by the police on the 8th ult. a 'call' from a signalling-post in Pall-mall, when the first window was broken, would have stopped further damage, and have thus covered the cost of the entire system to the State."

THE ELECTRIC LIGHT AND THE DALTON LOCAL BOARD.—At the last monthly meeting of this Board the Clerk reported, on behalf of the Electric Lighting Committee, that in accordance with the Board's resolution, Messrs. Menzies and Co. had been requested to state the grounds upon which they valued the second hand engine and boiler specified by their tender at £300, and read Messrs. Menzies' reply thereto, with details of estimate showing the amount specified. Numerous other letters, received since the last meeting of the committee from engineers and also from firms in relation to the supply of plant for electric lighting purposes, were read. Resolved that the Clerk request Messrs. Menzies' engineer (Mr. McWhirter) to furnish the date upon which he made, as stated by him, an inspection of the engine and boiler specified in the original tender, and to state if more than one inspection was so made. Read letter of 13th February from the Board of Trade stating that it would be necessary before depositing patterns that the Local Board should state the system of lighting proposed to be adopted:—(*a*) For incandescent lighting; (*b*) for arc lighting. Specifying full details as to efficiency in, and safety of supply. Read letter of 13th February from the Local Government Board, stating that a local inquiry would be held upon the Board's application for sanction to loan.—The report was, after a long discussion, adopted.

STEAM POWER FOR ELECTRIC LIGHTING AT THE COLONIAL AND INDIAN EXHIBITION.—Messrs. Davey, Paxman, and Co., engineers, Colchester, who supplied the whole of the steam power for driving the electric light machinery at the last three exhibitions at Kensington, have been retained for the same purpose for the whole of the indoor lighting at the approaching Colonial and Indian Exhibition. The steam power required amounts to 1,200 indicated horse-power, and will be supplied by nine sets of engines, comprising six types, namely, one compound semi-fixed engine, whose boiler has 670 square feet of heating surface, and working at a pressure of 120lb. per square inch; two sets of compound horizontal engines, three sets of vertical compound high-speed engines, all of different sizes; one compound horizontal girder engine, two pairs horizontal simple engines. The steam will be supplied to the semi-fixed engine by its own boiler, while that for the other eight will be generated in five boilers, at 120lb. pressure for the compound engines, and in six boilers at 90lb. pressure for the simple types, twelve boilers in all. Although 1,200 is the power estimated for, the engines and boilers supplied will, without any difficulty, give considerably more than this. As the firm supplying them have had such extensive experience in exhibition lighting, there is every reason to feel confident that the eminent success of their machinery at the last three exhibitions will characterise it this summer. We hope to give illustrations of the above next week.

THE NATIONAL ELECTRIC LIGHT ASSOCIATION.—At the first annual meeting of this Association, held recently at Baltimore, the President, during the course of his address, said the greatest problem that can now occupy the mind of the electrician is the generation of electricity directly by decomposition of the hydrocarbons, &c., without the intervention of the dynamo. The solution of this problem will simplify the production at the coal fields, &c., and the discovery will reward the one who makes it with untold wealth and honour. There is an immense field for activity in perfecting and applying thermopiles, accumulators, potential transformers, Geissler tubes, incandescent lamps, arc lamps, semi-incandescent lamps, meters, gas engines, &c., to electric light purposes. The engineer who applies himself to these subjects has a

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mine of wealth before him. Let him remember that electric lighting as a business did not exist ten years ago, and let him also recollect that the gas lighting is the largest manufacturing industry in the world, and that electric light will be welcomed in every place wherever gas has poisoned and blinded with its fume and flicker. At the close of the address, which was very cordially received, Dr. Moses made a few statements of a historical nature as to the fact that Pacinotti made his first machine as a motor, when the idea flashed across his mind that he would make it a generator—as shown by the attachment of a pulley and axles. It was strange that Pacinotti, with his thorough grasp of principles, as exhibited in the dynamo, had not arrived at the idea of its reversibility.

The Edinburgh International Exhibition.—One of the features of this exhibition will be a display of different systems of electric lighting. No fewer than 27 dynamos will be required to produce the necessary current, and these will be driven by 10 engines of the highest class, indicating 900 horse-power. Mr. Richard Millar, Glasgow, who is agent for Messrs. Thomson, Houston, and Company, holds the contract for lighting the permanent buildings, as well as the main entrance to the exhibition. The former are to be illuminated by 52 arc lamps, which should be amply sufficient to throw light into every corner. Down the central corridor of the temporary buildings, Messrs. King, Brown, and Co. are fitting up 1,444 lamps, which we believe to be the largest installation of electric lighting by means of incandescent lamps carried out by any company in the kingdom. To give an idea of the illumination of this portion of the exhibition, comparison may be made with the middle court at the Inventions Exhibition last year. In Edinburgh the court is 750ft. long, and with its 1,444 lamps, it will have one candle-power for every square foot flooring. The lamps are being fixed on the spearheads of the semi-circular roof. The centre spearhead carries three lamps, while the four on either side carry two. The whole system will be controlled from a massive coupling switch, by means of which the lamps will be instantaneously lighted or extinguished. Nearly all the wires have already been fitted up, so that there is no doubt that with ordinary care the installation will be completed in good time. The quaint buildings comprising "Old Edinburgh" are also to be lighted with incandescent lamps. This work has been entrusted to the Anglo-American Brush Light Company, who are preparing to fit in the wires for 250 lamps.

New South Wales.—Mr. J. Farnell, telegraph construction overseer at Tamworth, and son of Mr. J. S. Farnell, late Minister for Lands, has committed suicide. He bought a revolver, and went into the Coolabans Hotel. Soon afterwards a report was heard, and on a servant entering the room he found Mr. Farnell sitting on the floor against the sofa, with a five-chambered revolver by his side and a pool of blood on the carpet. A doctor was quickly in attendance, but found life extinct.—In regard to intercolonial cable messages, a contemporary says:—"It is not a little singular that, while the work which Mr. Burns set his hand to brought the Ministry to grief, the work which Mr. D. O'Connor, the Postmaster-General in the late Ministry, set himself to perform would have been of incalculable benefit to the traders and the press in the several colonies, as it was designed to cheapen the cost of intercolonial telegrams. It may be explained that the present subsidy of £7,500 a-year—of which New Zealand pays £5,000 and New South Wales £2,500—will expire in February next, and that the idea is to obtain a considerable reduction of rates in consideration of the continuance of the subsidy for a further term of five or ten years. Under the present tariff a message of ten words or under costs 7s., and every additional word 9d., no concession being made as regards press messages. It is to Mr. O'Connor's credit that, while in office, he succeeded in arranging —subject to the concurrence of the company's representatives at home, and of the New Zealand Government—that the tariff shall be as follows:—Ordinary messages, 6d. per word for every word contained in the message, no minimum charge being fixed; press messages, 3d. per word. The company was desirous of coupling the concession in regard to press messages with a stipulation that there should be a press guarantee of three times the number of words, but Mr. O'Connor did not see his way to agree to this stipulation. It is understood that the New Zealand Government strongly objects to continue the subsidy for more than the next five years, so that this objection may necessitate further communications with the directors in London."

City and Guilds of London Institute.—The following is the syllabus of a course of six lectures "On Some of the Industrial Applications of Electricity," by Prof. Ayrton, F.R.S., at the Central Institution, Exhibition-road, S.W., to be given from 5 p.m. to 6 p.m. on Friday afternoons, on the below-mentioned dates:—March 12th, "Electric Lighting": The lighting of houses, streets, trains, ships, lighthouses, and large areas with arc and incandescent lamps. Cost of electric lighting compared with that of gas or oil. Construction and regulation of arc lamps. Current potential difference, electromotive force, resistance and electric power. Mode of measuring electric power. Cost of a watt hour. Candle-power and efficiency of lamps. Mode of measuring. Life of incandescent lamps. Most economical potential difference to use with incandescent lamps. March 19th, "Electricity as a Motive Power": Construction and action of an electro-motor. Starting, stopping, and reversing. Power and efficiency of a motor. Mode of measuring. Effect of the speed on the power and efficiency. Action of an electro-motor compared with that of a dynamo. Governing of motors to run at constant speeds. Alternate current motors. Practical examples of machinery driven by electro-motors. March 26th, "Electric Storage of Energy": Accumulators, power, weight, and efficiency. Mode of measuring. Life of accumulators. Use of accumulators as regulators. Use as converters of electric power supplied with high potential difference and small current into power supplied with low potential difference and large current. April 2nd, "Electric Transmission of Power": Waste of power in the conductors. Advantages and disadvantages of the parallel system of supplying electric power. Economy effected by the use of the series, or the parallel series system. Most economical size of conductors. Heating of conductors. Uniform potential difference or uniform current along the mains. Use of accumulators, secondary generators, and motor-dynamos, in electric transmission of power. Utilisation of natural sources of power. Practical results already obtained with electric transmission. Comparison of electric with hydraulic and wire rope transmission of power. April 9th, "Electric Meters": Principles employed in constructing meters to measure current electromotive force, resistance, and power. Direct reading meters. Common faults in existing meters. Meters to record the total quantity of electricity, or the total amount of electric energy. Equitable modes of regulating the price of electric energy. April 16th, "Electric Locomotion": Tramcars carrying a store of electric energy. Electric launches. Methods of conveying electric power to moving vehicles. Electric, steam, horse, and wire-rope traction. Absolute blocking with electric railways. Telpherage. Probable future developments in the applications of electricity.

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TELPHERAGE.*

BY PROFESSOR JOHN PERRY, F.R.S.

(Continued from page 308.)

In place of this hanger we may substitute a seat, of which a side view is seen in Fig. 18, and an end view in Fig. 19.

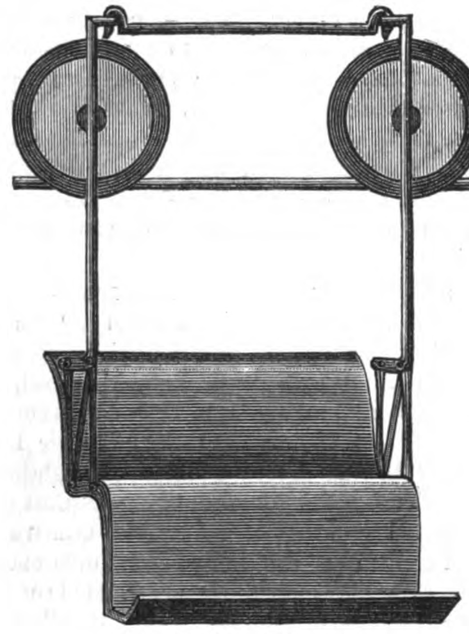

FIG. 18.—Seat (side view).

Two passengers can seat in it, and its weight is then nearly the same as that of each of the ten skeps when loaded, hence 20 passengers represent the load drawn by one locomotive. For passenger lines, however, it would probably be found more convenient to use a stiff rail rather than this flexible rod. Each skep weighs 101lbs., and when filled with clay its contents weigh about 250lbs. You will see that the hangers and buckets are insulated from the line, the cross-piece which connects the wheels being made of wood, so that the buckets may

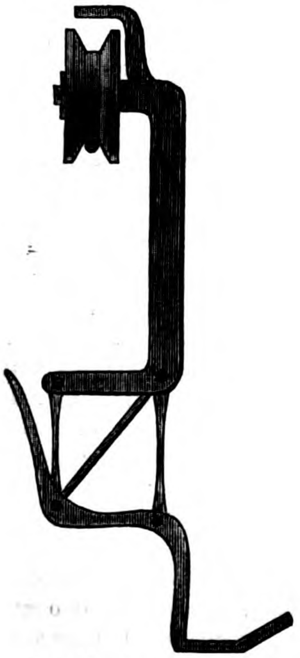

FIG. 19.—Seat (end view).

be handled without any shock being felt. Hence, should a dangerously high potential be used in working a telpher line, no danger need be feared from touching the buckets.

* Lecture delivered at the London Institution, 28th January.

This ingenious system of *single-wheeled skeps* (Fig. 20) we owe to the suggestion of Mr. Horace Darwin, of Cambridge, and the experiments of Mr. Gordon Wigan. A train of these single-wheeled skeps is now running before you in the model, and you will observe that while the friction has been greatly reduced, and the flexibility of the train increased so as to enable it to go more easily round curves, yet the practical handling of the skeps is as easily effected as the handling of the double-wheeled skeps. It is probable, therefore, that this is one of the improvements which we shall shortly introduce in telpherage. Mr. Wigan found that in the single-wheel skeps used at Weston there was a tendency for the wheels to alter continually in their distances apart, and that when a train was reversed in its motion it tended to buckle up, especially on curves. He found, however, that by putting the draw-bars, or rather the *draw-pins*, P, near the steel rod on which the skep wheel runs, the load in the bucket had an exceedingly great steadying action. His experiments were purely qualitative, and he contented himself by finding, from experiments made with the model train, a point of attachment for the draw-bars which gave good running. This point lies so close to the line that, owing to the necessary clearance in *underline* draw-bars, it was preferred to place them over the line and over the wheels. The problem, which is to be worked out by calculation and possibly by further experiments,

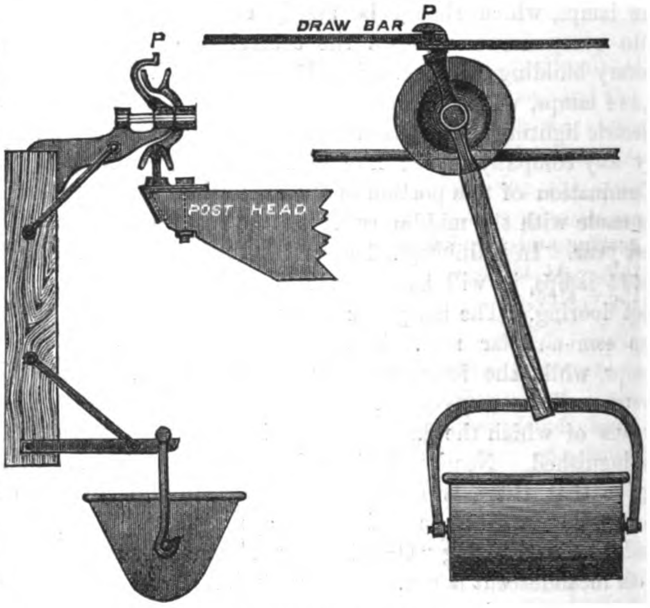

FIG. 20.—Single-wheeled Skep.

is to give the load such a leverage at the draw-pins as to prevent tilting and buckling, and yet not such a leverage as to prevent the swing of the load in the vertical plane under the line from acting as a *gravity buffer*, a matter much insisted on for all skeps by Prof. Fleeming Jenkin, and again well demonstrated by the experiments made for me by Mr. Wigan on traction in a line passing through the centres of the wheels, which mode of traction gives, of course, a practically rigid train. In this case the least obstruction on the line threw the train off, but when the draw-bars were placed so as to allow of a gravity buffer action, Mr. Wigan found that the model train would, on a straight part of the line, actually hop over a pencil rather than run off the line.

These single-wheeled skeps are very much cheaper than the the others, and they move with much less friction. Finding the one-wheeled skeps to run so well Mr. Wigan even suggested and tried a *one-wheeled locomotive*, and it, too, answered admirably on the model, so that we have every hope of producing a full-size cheap locomotive with only one wheel.

The "*Tandem Locomotive*," which is the type used at Glynde, is shown in Figs. 21 and 22, and a specimen of it is propelling one of the three trains in the model before you. This locomotive is very much simpler in character than the Telpher Locomotive shown in Fig. 3, and used with the Fitzroy street

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model, Figs. 4 and 5, and also much simpler than the locomotives described by Prof. Jenkin in his lecture delivered to the Society of Arts in 1884. A vast amount of ingenuity has been expended by Prof. Jenkin and the staff of the company in elaborating methods by which the rod or rail might be gripped very tightly between the wheels of the locomotive, and for driving these wheels from the motor. In this slide which I now throw on the screen, you will see some of the forms whose description is the most important part of Prof. Jenkin's paper to which I have referred. We find, however, that with the present very simple form of locomotive, shown in Figs. 21 and 22, we can

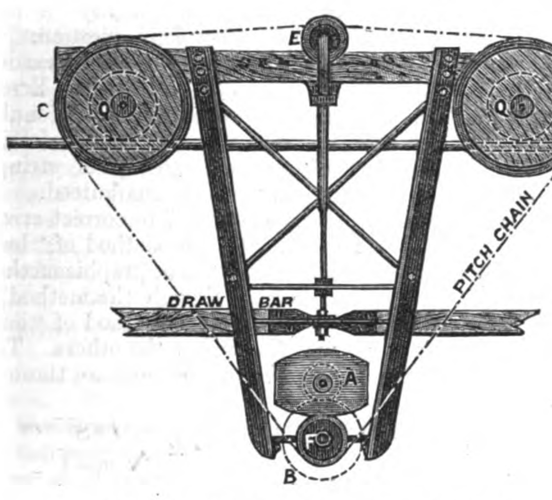

Fig. 21.—Tandem Locomotive (side view).

go quite readily up inclines which are as steep as 1 in 13, and we are therefore reserving the more elaborate forms of friction-gearing and grip-locomotives for such lines as are steeper than this. At Glynde, gradients have been introduced here and there, steeper than were absolutely necessary, and they enable us to see how readily a train may be drawn up an inclined part of the line.

Figs. 21 and 22 show that the frame of a locomotive now in use is made as light as possible consistently with stiffness and strength. It is suspended by two wheels Q (Figs. 9, 21 and 22), which have india rubber tyres fastened with cement to the iron underneath them, and which are also gripped at the sides. The speed of 1,600 or 1,700 revolutions

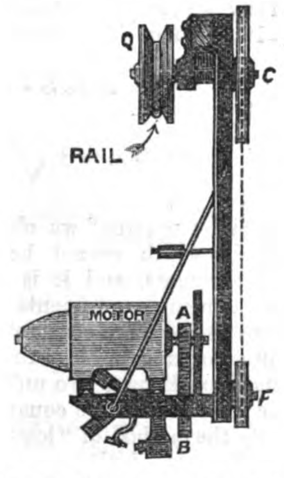

Fig. 22.—Tandem Locomotive (end view).

per minute of the motor is reduced by a pair of spur wheels at A and B to about five hundred, and on this second spindle there is a chain wheel F. (Fig. 22), so that a chain going round this wheel, and round two chain wheels at C, C, causes the two driving wheels of the locomotive to rotate. E is a little wheel which tightens the chain. Experience shows that the weight of the locomotive, which is not much greater than that of one of the loaded skeps, is sufficient, with these india rubber tyres, to produce a sufficient grip on the line for the propulsion of the train.

It is quite true that the pair of india rubber tyres will last only a fortnight in the wet season of the year; but we find that even on the wettest days the locomotive will perform its work quite well. In dry weather the life of the india rubber tyre is of course very much longer. Should the rod on which the train runs be kept quite dry, I have no doubt that this simple form of locomotive would be sufficient for as steep a gradient as even 1 in 10. We have only tried one plan for artifically drying the line, by scraping the line with a piece of india rubber carried in front of the locomotive. As, however, the locomotive performs its work quite well without any such artificial drying, we prefer to leave the line in its natural state. Of the three kinds of material which we have used to make the tyres of—metals, leather, and india rubber—the india rubber has been signally the best.

Some of you may be astonished to find that this small locomotive running on the model can exert a pull and push sufficiently great for the propulsion of trains on this flexible line. In the real telpher line, when the locomotive is climbing to a post, we are particularly struck with its propelling power, even when we are told that only one mechanical horse-power is required to be exerted by the locomotive. In fact, our eye deceives us, and we imagine that the propelling power on a flexible line like this, where the rods sag down very much when the trains pass over them, and become quite straight to the eye after the trains have passed, must be much greater than it would be on a rigid rod. But this is not the case, careful experiments having shown that the propelling power on such a flexible line when the train is made to cover one or two or more spans completely, and not any fraction of a span, is pretty much the same as on a stiff line, because there is always the same amount of weight descending on the flexible line as there is ascending to a posthead, so that the weight of one part of the train balances that of the remainder all the time.

The motor now in use at Glynde is of the Reckenzaun type. As the bad insulation of the motors in telpherage may be regarded as the only weak point of the whole system, we are directing attention now, with the help of Mr. Reckenzaun and Mr. Immisch, to obtaining the best form of moter, which can be left to work by itself for a long time without breaking down in insulation or requiring the adjustment of the brushes, and which shall, like the other moving parts in telpherage, require but very little attention in oiling. We find that unless motors, as they have hitherto been made, are closed up very much more completely than it is possible to cover them on a telpher locomotive the insulation is very likely to suffer in damp weather when a train is not running. Luckily, however, if a small current which is insufficient to work the line is maintained for a short time through the motors before the day's work commences, the evil effects may be got rid of. Each of the motors at Glynde receives a power of about 1,500 watts, or about two horse-power, and as the potential is about 200 volts everywhere on the line, each motor receives about 8 amperes when a train is running at about $4\frac{1}{2}$ miles per hour. We have not observed that the constant reversals of the current that occur as the locomotive passed over the post heads has produced any evil effect on the dynamo machine, which is a Crompton shunt machine of the Gramme type, capable of giving out steadily a current of 24 amperes at a potential of 200 volts.

The engine which drives our dynamo machine is of a simple agricultural type, and is at present regulated by what is known as a Willans governor; but this method of governing will probably in future give place either to a less costly and more efficient arrangement, such as that of compound winding of the dynamo which is now well known, or we shall use no governors at all, as the trains themselves are governed to run at the same speed up or down an incline. The governor on the engine is supposed to maintain the potential at the poles of the dynamo steadily at 200 volts, admitting more or less steam to the engine for this purpose, and at the part of the line most distant from the engine house we do not find that at Glynde there is a much greater falling off in

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potential than from 10 to 12 volts, so that the loss in transmitting power to the farthest end of the line is not more than about one-tenth of a horse-power.

(To be continued.)

EFFICIENCY OF THE EDISON-HOPKINSON DYNAMO.

A number of gentlemen, at the invitation of Messrs. Mather and Platt, of the Salford Iron Works, Manchester, gathered together at the works of the firm on Saturday, February 27th, to witness some experiments with the Edison-Hopkinson dynamos. The immediate cause of these experiments was a suggestion of Dr. John Hopkinson, made during the discussion of Mr. G. Kapp's paper, read before the Institution of Civil Engineers, to the effect that measurements relating to the efficiency of dynamos were not nearly so accurate as they might be. When Faraday was asked to witness an experiment, he wished to know beforehand what he was expected "to see." The following paragraphs from a circular distributed to the visitors by Messrs. Mather and Platt will answer the question, "What went ye to see?":—"Up to the present time the method adopted for determining the efficiency of conversion from mechanical to electrical energy by dynamo machines has consisted in a direct measurement of the power transmitted to the dynamo through the driving belt by a transmission dynamometer, and the determination of the electrical power developed outside the machine. The latter portion of the experiment presents no difficulties, and even when large powers are dealt with a high degree of accuracy is easily attainable; but all who have used a transmission dynamometer know that it is exceedingly difficult to obtain accurate results, even when the utmost precautions are taken, and the difficulty is vastly increased when large powers have to be dealt with. If the power transmitted amounts to 50 horse-power or upwards, probably few experimenters would undertake to guarantee the accuracy of the observation within limits of even 2 or 3 per cent.; and the determination of the efficiency will be erroneous precisely in proportion to the error in the dynamometer. Probably, therefore, no efficiency experiments hitherto made on a large scale can be regarded as having any certainty of accuracy within at least 3 per cent."

As we have said, "Dr. John Hopkinson suggested an entirely new method by which the efficiency of conversion can be determined with great ease, and which is not open to the above objection. The method also throws light upon other points of great interest, and especially on the much-discussed question as to the relation between the dynamo when used as a generator and motor respectively.

"Let two dynamos, approximately equal in dimensions and power, have their shafts coupled by a suitable coupling, which may serve also as a driving pulley; and let the electrical connections between the dynamos be made so that the one drives the other as a motor. If the combination be driven by a belt passing over the coupling pulley, the power required to be transmitted by the belt is the waste in the two dynamos and the connections between them. Moreover, by suitably varying the magnetic field of one of the dynamos, the power passing internally between the two machines can be adjusted as desired. If, then, the electrical power given out by the generator is measured, and also the power transmitted by the belt, the efficiency of the combination can be at once determined. The beauty and advantage of the arrangement lies in the fact that the measurement, which presents experimental difficulties, is of a small quantity, viz., the power transmitted by the belt. Consequently, even a considerable error in the determination has but a small effect on the ultimate result. On the other hand, the measurement of the large quantity involved—viz., the electrical power passing between the two machines can, without difficulty, be made with great accuracy. Assume, for example, that the generator dynamo gives 50 horse-power, and the motor provides 40 horse power of this amount; then the driving belt has to supply 10 horse-power only, and an error of 3 per cent. in the measurement of this quantity would cause an error of only 0·6 per cent. in the final result. The method thus obviates entirely the objections to other methods formerly employed, and has, at the same time, the advantage that the actual mechanical power transmitted to the machines is small, and therefore more readily dealt with by the dynamometer. In fact, an error of ½ per cent. may be considered as the extreme limit, if ordinary precautions are taken."

Before stating the actual results of the experiments, it may be interesting to some of our younger readers, and those who have had little experience of "exact" work, to refer to some of the methods usually employed to eliminate errors. It is seldom that an experiment furnishes at once the information required, and generally more or less laborious calculations have to be made if any pretension to accuracy is in question. In reading from a scale, and especially in many electrical measurements, a mistake of one degree may easily be made. Errors of observation may be, and generally are, eliminated by multiplying observations. But, when we have to deal with defective apparatus, such as friction of pulleys, rigidity of strings, radiation, the absolute accuracy can never be guaranteed.

The three methods most usually employed to correct errors of observation are (1) the graphic, (2) the method of "least squares," and (3) the method of "means." The graphic method is coming more and more into vogue, though the method of "means" is by far the most general, while the method of "least squares" is perhaps not so well known as the others. The following formulæ, using the method of means, are those to obtain:—

Mean error of a single observation $= \pm \sqrt{\frac{S}{n-1}}$

Probable „ „ „ $= \pm \frac{2}{3}\sqrt{\frac{S}{n-1}}$

Mean error of result $= \pm \sqrt{\frac{S}{n(n-1)}}$

Probable „ „ $= \pm \frac{2}{3}\sqrt{\frac{S}{n(n-1)}}$

where S = the sum of the squares of the deviations of the result of each observation from the arithmetical means.

Take an example of some readings from an ammeter. Thus if $C = 119·5$, $C_1 = 119·7$, $C_2 = 119$, $C_3 = 120$; the most probable value of

$$C = \frac{119·5 + 119·7 + 119 + 120}{4} = 119·8$$

Then

$$(119·8 - 119·5)^2 = ·3^2 = ·09$$
$$(119·8 - 119·7)^2 = ·1^2 = ·01$$
$$(119·8 - 119·0)^2 = ·8^2 = ·64$$
$$(119·8 - 120·0)^2 = -·2^2 = ·04$$

Here S = ·78

and using the formula we get—

$$\text{Mean error of observation} = \pm \sqrt{\frac{·78}{3}} = \pm ·54$$

and so on.

In the method of "least squares" we obtain equations containing the magnitude which cannot be directly observed together with other constants, and it is necessary in using this method to make as many experiments as will furnish data for as many equations as there are constants to be determined. This, of course, is in accordance with ordinary algebraic work, where, as every schoolboy knows, two unknowns require two equations, and three unknowns three equations, in all his ordinary calculations. By the method of "least squares" a value is calculated such that the sum of the squares of the differences between it and the observed values has the smallest possible value. In the usage of the method of "least squares," a graphic method is frequently used for the interpretation of experimental results, from the study of which "interpolation formulæ" are deduced.

With the graphic method, a series of points are obtained the position of which is determined by ordinates and abscissæ. Usually the points obtained experimentally do not form any regular curve, but so that a curve may be drawn with half the ordinates of the points terminating on one side the curve and

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half on the other, the curve showing where the points should come if no errors of observation intervened. To interpret some of these curves requires a knowledge of the calculus.

We have thus briefly referred to the difficulties in the way of exact measurements, and the methods usually employed in minimising the errors. Exactness, again, depends largely upon the simplicity of the operations and the values of the quantities to be measured. The measurements in a draper's shop, for example, are approximate only, and although it is not important to obtain great accuracy in measuring a yard of calico, the error in very large quantities may be appreciable and of importance.

Dr. Hopkinson's suggestion with regard to dynamos was, as we have seen, in the direction of simplicity and smaller quantities to be measured. In fact, he measures the small resultant instead of the whole of the forces. The most elementary school books tell us that the resultant of two forces is nil when the forces are equal and opposite, and that the resultant of two forces acting in the same or opposite directions is the algebraic sum of the forces. Thus, if they act in the same direction, the resultant will be the sum of the two; if they act in opposite directions, it will be the difference of the two, and while the forces may themselves be very large, this difference may be comparatively small, and the measurement of the difference will lead to a much smaller observational error than the measurement of the forces themselves. This elementary proposition embodies the suggestion of Dr. Hopkinson, who, as we have seen, couples the shafts of two approximately equal dynamos, and makes the connections so that the power required to drive the generator is partly returned by the power given out by the motor. If the two machines were absolutely equal in all respects, and the apparatus such that no loss of any kind took place, the power absorbed by the generator would be given out by the motor, and no work would be required from the engine. The experiment witnessed on Saturday may be thus briefly described. Power

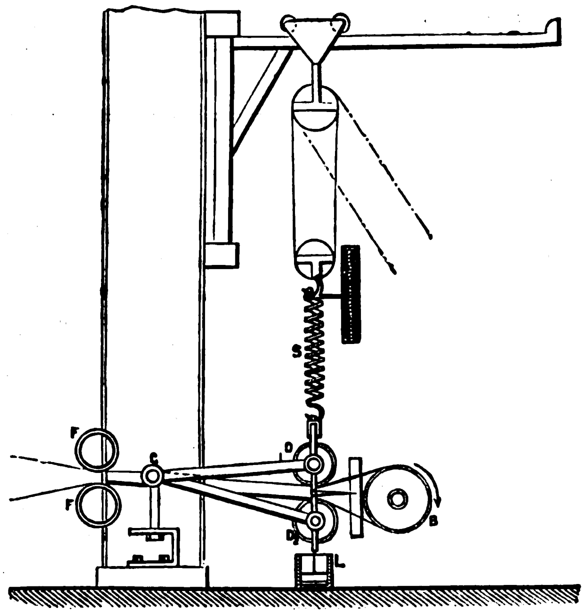

Fig. 1.

was obtained from an engine to drive a dynamo acting as a generator. The current thus obtained was used to actuate a motor, and the motor developed mechanical energy which was returned to, or, so to speak, assisted, the engine. When driving the generator alone the engine would be required to do certain work, but when the connections were made to the motor the amount of work required from the engine was greatly lessened.

The two machines experimented with were of the well-known Edison-Hopkinson type, with all the latest improvements introduced by Dr. John Hopkinson and Messrs. Mather and Platt. The dynamos are similar in all their dimensions and winding, and are each intended for a normal output of 110 volts, and 320 amperes, at a speed of 780 revolutions per minute. They are both shunt-wound only, and have solid wrought-iron magnet cores and field pieces. The commutators are of copper, insulated with mica, with 40 bars. The general arrangement of the dynamometer is shown in Fig 1. It is of the Hefner-Aleneck type. In the figure, B shows the driven coupling of the dynamos; D, D the guide pulleys of the dynamometer turning about the fulcrum C, and supported by springs, the tension of which is read by a pointer against a fixed scale, when the index of the dynamometer is brought to its fiducial mark. L is a dashpot, F F are guide pulleys, bringing the belt parallel with the dynamometer. The potential between the terminals of the generator was measured by a Thomson graded galvanometer, previously carefully standardised by a Clark cell, and the current by passing it through a known resistance; the difference of potential between the ends of the resistance being determined by Poggendorf's method by direct comparison with the Clark standard cell.

The resistance of the armatures and magnets of the two machines is as follows:—

Generator......	Armature............	0 009947	ohm.
	Magnets	16·93	„
Motor	Armature............	0·009947	„
	Magnets	16·44	„

During the experiments made with these machines a current of 521 amperes was passed through the two armatures in order to test their mechanical strength, this current being nearly double that for which the machines are designed. They were found to carry this current with perfect ease without any sparking at the brushes or displacement of the wires of the armature. Such a current maintained for any length of time would lead to undue heating of the armature, but the fact is of importance as showing that a momentary short-circuiting of the machine would not result in serious mechanical damage to the armature, and especially that, when the machines are used for transmission of power, for a short time they are capable of giving about double the output required of them for regular working. In connection with locomotive power this is a matter of considerable importance, as frequently on a short incline or in starting the cars a far greater tractive force is required than during normal working.

The dynamos above described and tested, it may be mentioned, are intended for the new tobacco manufactory of Messrs. W. D. and H. O. Wills, of Bristol.

We had hoped to have ready a perspective view of the dynamos and dynamometer as arranged for the experiments, but some delay occurred, and the photographs were not ready in time to be engraved for this issue, so that we shall defer the results of the actual experiments to next week, merely saying that the figures obtained showed an efficiency of 90 per cent.

(To be continued.)

Electricity and Mining.—A few days ago a party of gentlemen interested in mines assembled at the Granville Deep Pit, Upper Hanley, to witness some experiments in blasting with a safety cartridge, of which Mr. Miles Settle claims to be the patentee. The patentee claims for his cartridge that, when exploded, the flame is so protected, and after the act of explosion extinguished, that it does not communicate with the outer air, and that therefore, in the presence of inflammable gas, it is absolutely safe. The cartridge, which has often been described, is 18in. long, and contains dynamite or tonite floating in water, enclosed in an oilskin bag. One cartridge was carefully placed in each hole, and a tamping of soft clay put next. After that the holes were stemmed and rammed in the usual way, the electric wire being left in in contact with the percussion at the head of each cartridge. The party then retired a distance of ten yards to the battery, and all lights were removed. The whole was fired simultaneously, and brought away about fifty tons of coal. In this seam the face comes away with very little dust, and on this occasion there was almost none. In the absolute darkness no flame from the electric spark or the explosion of the dynamite was visible, and the result of the experiment was pronounced to be entirely satisfactory.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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ANSWER TO CORRESPONDENT.

SOLON.—*There is no such instrument as yet, but the King of the Belgians has offered a prize with the object of stimulating research in the direction you refer to.*

ELECTRIC DISTRIBUTION.

The Electric Lighting Companies whose business prospects were discussed in our last week's leader have other reasons for congratulation beyond those dwelt upon in their several Reports. Any of the shareholders who were present at the meeting of the Society of Arts on the 17th ult., when Prof. FORBES read a paper on some points in Electrical Distribution, will understand what we mean when we say that the legal and the financial obstacles to the progress of the new illuminant have not been the only or chief causes of failure. It is true that the hindrances just specified have been great, and in any case might have proved insurmountable. Prof. FORBES dwelt with sufficient emphasis upon these, giving it as his opinion that no sane man will invest his money in speculations hampered by the conditions imposed under the Electric Lighting Act of 1882; and he added something to the stock of argument against that measure by pointing out the very questionable conduct of statesmen who, while professing to guard against the creation of fresh monopolies, enacted a measure which was certain to leave the old monopolies in undisputed possession. "If (said he) the gas monopoly was truly so very irksome, the encouragement of a rival illuminant would have been the best cure for the evil; whereas our legislators acted as if they were parties interested in maintaining the gas monopoly, for they imposed such restrictions as rendered it impossible for electricity to be supplied to the general public;" and he urged, as we ourselves have repeatedly done, that electricity should be allowed to compete with gas under precisely similar disabilities and with equal advantages. "This is not doubling a monopoly; it is splitting it into two, and destroying the monopoly by admitting open competition." As to the financial difficulties which have beset the undertakings from the very beginning, they are hit off to a nicety in his reply to American critics who have questioned the soundness of Prof. FORBES' scientific calculations, because they do not confirm the extravagant promises of Company prospectus mongers. Singling out a sample by way of illustration, and examining it under the light of ascertained facts, he significantly observed that "this manipulation of figures may suit American financiers, but it is *not* electrical engineering."

With equal candour, however, the lecturer admitted that there had been faults on the part of the profession just named. Electrical engineers had not conducted the work with which they had been charged as carefully and conscientiously as they ought; and they had especially erred in grudging the necessary amount of forethought and calculation in preliminary arrangements, so as to secure the best results by the most economical means—a want of caution the more reprehensible seeing that existing data were imperfect and the whole business novel. It is in these respects that promoters may now find grounds for encouragement in the clear and concise account of the rapid progress scientific workers have made in supplying trustworthy bases for future operations, as well as in the marked improvements rendered available by practical experimenters. In respect to the former very little need be said. It is hardly an exaggeration to say that the whole energy of the scientific world has latterly been concentrated upon the phenomena of electricity; and it is certain that our exact knowledge of this subject has increased beyond all precedent under the impulse which a promising industry has created. As to practical inventions, they have more than kept pace with theoretical speculation. It is difficult to separate the two, and it is perhaps useless to attempt it; but, to name only a few improvements which are likely to stand the test of practice, there is the important step recently taken to regulate the glow lamp by altering the length of the filament; then there is the improved shunt, which promises to relieve us of the inconvenience of a breakage by introducing a resistance not too great to seriously affect the ordinary circuit. The construction of the lamps are vastly superior to what they were even a year ago, and the same may be asserted of dynamos all round. The automatic cut-out, and the electric current meter are also now in a condition to satisfy the requirements of any electric lighting Act, or the stringent regulations of insurance companies. Altogether, we agree with Prof. FORBES that the facilities now at the disposal of the engineer for designing satisfactory schemes of electric lighting, and which have been added to his store during the past year, are very abundant.

Improvements in secondary batteries which promise to become an almost indispensable factor in every electric light installation of the future have been not less numerous and important. Indeed, it was to the consideration of these adjuncts to the electric generator that the lecturer devoted a great part of his discourse on the distribution of electricity. The economical advantage of employing secondary batteries is obvious, notwithstanding the first loss of energy; but until recently the attempts to employ them in dis-

tributing stored electrical energy over wide areas have wholly or partially failed, for want of an indicator, to inform us of the condition of the cells, and because the personal inspection of an attendant was constantly necessary. These storage cells are now constructed so as to last for a considerable period. But what is wanted more particularly is that they should take current from the dynamo only when they require it. Something is required in the nature of a switch to act with the state of charge. Fortunately more than one device is now on trial which promise a satisfactory solution of the difficulty; and even without it there are many installations on such a scale as would warrant the employment of attendants to examine the condition of the cells at frequent intervals. Practical experience has demonstrated the useful fact that secondary batteries can be employed with economical advantage in large districts, while in small areas a direct service is the cheapest.

Of the new form of appliance called transformers, patented by Messrs. GAULARD and GIBBS, although we cannot speak of it with such positiveness, we are disposed to regard it with even greater hopefulness. By one of those common, but none the less strange, coincidences M. GAULARD has devised by actual experiment a remarkably perfect secondary generator on principles the true nature of which were being simultaneously elucidated through the insight and dexterity of Prof. HUGHES. It is in reality an induction coil; but constructed on lines which the induction balance has shown to be theoretically perfect. The loss of energy in charging it is quite inconsiderable; and if its serviceableness in other respects answers to the predictions of its friends, there will be no objection to it on the score of waste. The bearing of these inventions on the problem of electrical distribution will be seen if we quote a sentence from Prof. FORBES' lecture, "Suppose we use 10,000 volts, we may have 100 generators in series, each using 100 volts, or we may make any other arrangement. If it were done as I say, then a wire of one square inch section will carry current enough for 100,000 lamps, each consuming 60 watts." Moreover, any desired variation in the circuits could be attained with the greatest facility; and, according to M. GAULARD, if the leads in this arrangement consist of two parallel wires, and currents in opposite directions are sent through, not only no induction on the external circuit will appear, but no self-induction on the two leads can arise.

CORRESPONDENCE.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is not my custom to reply to reviews of any of my works, but the writer of the friendly notice of my "Dynamo-electric Machinery" in your last issue has fallen into two mistakes which concern not so much my work as the general scientific questions involved. As he is not alone in his misapprehension, I think it may be well for me to send you a brief correction of the points.

First, he says (p. 309) "It would also be well to finally abandon the figure 746 as representing the number of watts corresponding to 1 horse-power. We know from Lord Rayleigh's determination of the ohm and of the volt that the exact figure, neglecting fractions, should be 736, and think it high time that the correction should be made in all new books." Now, whatever Lord Rayleigh may or may not have done, his work has not altered the definition either of the horse-power, the watt, the ampere, the ohm, or the volt. All he has done has been to show that the B.A. unit of resistance was less than one ohm, and that the B.A. unit of E.M.F. was less than one volt. The watt is *not* the product of one ampere into one B.A. unit of E.M.F.: a watt is *not* equal to the rate of expenditure of energy when one ampere flows through one B.A. unit of resistance. The watt has been settled once and for all as the product of one ampere into one volt, and is therefore equal to ten million ergs per second. No other definition has ever been even suggested. The horse-power is defined as equal to 33,000 foot-pounds per minute (at London). No alteration in this value has been suggested by Lord Rayleigh, or in consequence of his work. These being the definitions, there can be no question as to the essential correctness of the figure 746. I give the calculation in full:—

1 volt $= 10^8$ absolute units of E.M.F. (C.G.S. system)
1 ampere $= 10^{-1}$ " " of current (" ")
1 watt $= 1$ volt-ampere $= 10^7$ ergs per second
1 H.-P. $= 33{,}000$ foot-pounds per minute (at London)
$= 550$ foot-pounds per second (at London).

So far, these are definitions about which there can be no dispute.

1 foot $= 30{\cdot}4797$ centimetres
1 pound $= 453{\cdot}59$ gramme
gravity $= 981$ "centims-per second-per second" (at London)
Hence, weight of 1 pound (at London) $= 453{\cdot}59 \times 981$ dynes
" " " $= 444972$ "
Whence
1 foot-pound (at London) $= 444972 \times 30{\cdot}4797$ ergs
" " $= 13{,}562{,}601$ "

Therefore,

$$1 \text{ horse-power} = 550 \frac{\text{foot-pounds}}{\text{sec.}} = 550 \times 13562601 \frac{\text{ergs}}{\text{sec}}$$

$$1 \text{ horse-power} = 7{,}459{,}440{,}000 \frac{\text{ergs}}{\text{sec}}$$

$$1 \text{ horse-power} = 745{\cdot}944 \times 10^7 \frac{\text{ergs}}{\text{sec}}$$

whence, finally,

1 horse-power $= 745{\cdot}944$ watts.

If the writer of your notice had said that one horse-power was equal to 736 of the products (not watts) of amperes into B.A. units of E.M.F. (not volts), I should still object; for if he uses units that are smaller than the true ones his reputed watts will be too many, and to bring them to horse-power he ought to divide not by 746, nor by 736, but by 756 or some greater number. For my own part, I do not use B.A. units of E.M.F., nor B.A. units of resistance, nowadays; nor do I call them volts and ohms when I know that they are not such, but are less than the volt and the ohm respectively. As a plain man who calls a volt a volt and an ohm an ohm, I write, and shall continue to write, 746 watts equal to one horse-power.

The other point in which I wish to offer a correction to your notice is the statement of the writer that "a motor has no critical speed." He must pardon me if I venture to say that he is not aware of the proper use of the term "critical speed" in relation to self-regulating dynamos and motors. He uses the term "critical speed" in the sense of that speed below which the dynamo refuses to excite itself. Of course, if he wishes to make that definition he is entirely welcome, only it is not the sense in which the term has been used by me, or, before me, by other writers on dynamos, notably Profs. Ayrton and Perry. If the sense in which the writer of your notice uses the term were correct, then no magneto-machine or separately excited dynamos could have a critical speed. As I and those before me have used the term it has been used to signify that speed at which the characteristic curve of the machine runs approximately parallel to the line that represents (by the tangent of its slope) the armature-resistance. And in this sense every motor has a critical speed, utterly independent of the question whether its field-magnets are excited by the same current that runs through its armature, or whether they are excited in any other way.—Yours, &c.,

SILVANUS P. THOMPSON.

Finsbury Technical College,
March 1, 1886.

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CABLE-LAYING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of Feb. 26, page 301, you ask how is it that considerable errors are often found in the position of cables laid close in shore, where, it might be supposed, no difficulty should exist in plotting those positions accurately.

Cable engineers constantly find a certain amount of incorrectness in the details of all existing charts, and for the work which your paragraph refers to not even the charts of the English Channel should be trusted too implicitly.

During the surveys effected for the construction of charts the points used for cross bearings or triangulation are frequently carelessly sketched in; it consequently happens that the same points are not taken by different observers. In order to obviate this error, to a certain extent, it is usual in plotting a coast cable to mark on the charts the points used in the original observations, and to sketch in the salient or most remarkable features of the coast with their respective bearings and angles.

As will be easily understood, the error of plotted position due to incorrectness in the chart diminishes as the distance from the shore increases, but when close in shore a very careful selection of the points to be used in plotting the position of the cable is absolutely necessary.

It is well that *The Electrician* has drawn attention to this question, as many men new to cable work must often have been puzzled at the discrepancy between their results and those obtained by other observers.

The choice of points on shore demands a certain amount of experience, for not only must the most salient spots be quickly chosen, but those positions must be selected which are likely to be accurately laid down on existing charts. This very important branch of the work should be carefully studied by young cable engineers, and in order to be accurate in their observations, they must remember that the relative positions of all points on an admiralty sheet are not laid down with mathematical precision. Indeed, so much is this the case, that it is frequently necessary to construct a special chart for the work in hand, or at all events to correct the existing surveys.—Yours, &c., W.

THE MONOPOLY IN TELEPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have spoken to a considerable number of gentlemen, of many nationalities, interested in the telephone, *but outside the monopoly*, as to the advisability of holding a conference in London or Paris to discuss the telephone in general, investigate claims, and consider what steps, if any, it will be advisable to take to protect the public and the electrical profession against the present monopoly, and all agree that such a conference is most desirable, and have promised to give the scheme all the support and assistance in their power. As it is impossible to see every one personally or communicate, I shall be glad to receive a line from all who are willing to assist with advice or information, or who would be desirous of attending the conference, admission to which will be by ticket only.

Any suggestions will be thankfully received.—Yours, &c.,

W. E. IRISH.

Rosemont Lodge, Richmond, Surrey, March 1, 1886.

RESISTANCE AS VELOCITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: No one has ventured to rebuke Mr. Swinburne for his very flippant treatment of this serious subject in your issue of Feb. 19th. Is this because no one really believes that "resistance is of the nature of velocity?" Yet, I quite recently heard a distinguished physicist use those identical words! The process by which resistance is converted into velocity reminds one of the small boy, who, having a complicated rule-of-three problem given him, calmly proceeded to reduce acres to pence, with deplorable results (from his point of view). The next time Mr. Swinburne feels his common sense outraged, let him contemplate the change-ratio for resistance expressed in electrostatic units—viz., $R = [T L^{-1}]$; what does that mean? The right hand side does not look like velocity. Shade of Maxwell! Can it be that resistance is occasionally of the nature of *slowness?*—Yours, &c. SYDNEY EVERSHED.

Kenley, Surrey.

ELECTRO-CHEMICAL EQUIVALENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your issue of the 26th ult. contains a review of Prof. Silvanus Thompson's "Dynamo Electric Machinery," and in it you call attention to the data respecting the electro-deposition of copper. I may, perhaps, therefore, be allowed to call Prof. Thompson's attention, through the medium of your columns, to the discrepancy between the electro-chemical equivalents as published in his "Elementary Lessons in Electricity and Magnetism" (*a*), and the data contained in his "Dynamo-Electric Machinery" (*b*).

Grammes per Ampere Hour.

	Copper.	Silver.	Gold.	Nickel.
(*a*)	1·1905	4·0824	2·4732	1·1124
(*b*)	1·1739	4·0250	2·4410	1·0990

The two sets of figures have evidently been calculated from different data. In the "Lessons" the datum appears to be that if the electro-chemical equivalent of hydrogen taken as ·0000105 gramme per coulomb; and if the other figures have been calculated from more recent or more reliable experiments, we shall have to alter our values for all the other metals.

If Prof. Thompson will kindly explain this he will doubtless confer a favour on others besides myself who are anxious to make use of the correct data.—Yours, &c., W. K.

INFORMATION WANTED.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you please inform me where hygrometers are for sale or made, such as Mr. Shoolbred spoke of in your number of Feb. 26? May I also trouble you to inform me what instrument is used for splitting the current of a series Gramme machine for the purpose of running two "Serrin" lamps? I have asked this question several times, but nobody seems willing to part with such knowledge. I was informed such an arrangement was often effected by the use of a coil, but the name of the coil was forgotten. May I also ask what is the regulation size wire to carry a current of 20 amperes the distance of four hundred yards?

Hoping you will pardon my stupidity, and that you will kindly assist me to gain this knowledge.—Yours, &c.,

London, W., February 27. A STRANGER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you or some able correspondent kindly give me some experiments with the telephone, as I am getting up a lecture on the same, and am at a loss for experiments.

A reply through your columns or the post will be esteemed. —Yours, &c., GRAHAM CAMP.

William-street, Norwich, March 3rd, 1886.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am sorely puzzled, and should feel very thankful if you or any of your readers will kindly give me an answer to the following question:—

Is there any telephone line of 100 miles or more in length being worked regularly and satisfactorily in the United Kingdom or any other part of the world, and if so, where?

On pages 166, 186, and 265 of your Vol. XV. you have told us that very satisfactory *experiments* have been made in different places up to 200 miles, and I have frequently read of

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speech being transmitted over what I believe to be impossible distances in America; but, if I heard correctly, Mr. Preece told us on Thursday evening last at the Society of Telegraph-Engineers and Electricians that it was not possible to work the telephone *in a practical manner* between London and Birmingham.

Surely over such a distance as this (113 miles) it is merely a question of *insulation*—a matter, by the way, which does not seem to receive so much attention as it deserves from some of our telephone companies.—Yours, &c., TELEPHONE.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: "Horrors on horrors still accumulate" (Macbeth). There was one Electric Boy, and now there are two, operated apparently on rival systems. Let us hope this reduplication will spread to Electric Cows; then the three acres will be all that is needed to realise the working man's millennium. But, on the other hand, it would be a national calamity if it extended to Electric Bugs. I have felt it my duty to order a double supply of insect powder.—Yours, &c.,

W. H. STONE.

Oxford Villa, Geraldine-road, Wandsworth, S.W.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My note, p. 214, applied to "the Electric Boy" exhibited at the place mentioned on p. 131, and sufficiently answers Nos. 1 and 2 questions on p. 311. If Mr. J. does not understand, I can only say I thought he would have done so, though my letter was not addressed to him or intended to convince him.

He is entitled to no reply from me, however.

I did not say, nor did you, Mr. Editor, by the word "knew," intend to suggest that I possessed the name, address, or honour (?) of the personal acquaintance of either of the pennyshowmen in the sense Mr. J. seems to imply. His ingenious postscript, p. 311, however, throws a new light on the whole matter, for it is evident he understands my remarks did not apply to *the other boy*; and as it will please him best I leave him to place whatever construction he chooses upon this sentence.

Quoting his own words, "it is now manifestly the duty" of Mr. J. to produce the boy, or give name and address where same may be seen, to those who may be sufficiently interested to pursue the matter further. The existence of a boy capable of giving off electricity without any battery or extraneous source, *when removed from contact with conductors, from the care of showmen and confederates, and specially from any particular room or building* is the logical inference from Mr. J.'s letter.

If there *is* no such boy, or until (with all due respect to Mr. J.) such a boy has been *proved* to exist, by evidence vastly stronger than his, or any other person's, mere unsupported statement, his theories ought to be kept *near* home and well taken care of.

I confess I was myself very much "shocked" when I read his account of the "only way" in which the doses—all of which, I presume, contained "their normal quantities of latent electricity"—"could have" had effect upon the wonderful cow. I have since had his letter thereon (p. 292) tried upon a number of electrical engineers in ordinary normal condition. They have uniformly been "positively electrified" as a result of the "operation," but the "opening" of their pores (?) was apparently due to "local action," specially noticeable in the facial region.

I quite concur in Dr. Stone's last remarks, and for my own part shall take no notice of any more correspondence on this subject, or encroach thereon further on your valuable space.—Yours, &c., HAMLET.

P.S.—Both of the showmen suited their statements to their visitors' idiosyncrasies, but one had special facilities for knowing same.

THEORY OF MAGNETO AND DYNAMO MACHINES.

XXIX.*

We have now discussed the generation of E.M.F. in a revolving armature under the influence of a given magnetic field. We have seen that the E.M.F. is calculated from the rate of change in the total number of lines of force passing through the coils, those due to its own current as well as those due to external field; and we have found that the main effect of self-induction is to add a spurious resistance $\frac{dL}{dt}$, so that the effective or apparent resistance of a spinning armature is no longer R—the value it has when at rest—but $R+4\nu L$, where L is in practice a constant to be determined by experiment, and ν is the number of revolutions per second.

It only remains now to consider the way in which the field is actually produced, and to show how some theoretical approximation to its strength can be made.

Everything depends on the number of lines of force which can be got to go through the armature coils, and it is most important to make them as numerous as possible. The whole power of the machine depends, in fact, upon N, the number of lines which the field-magnet is able to send through the armature.

To Calculate the Value of N in an Ideally Perfect Machine.—Recall certain results already obtained. The number of lines belonging to a simple magnet, or magnetic filament whose strength of pole is m, is $4\pi m$.

The moment of a magnet is ml, where l is the distance between the magnet poles measured straight. In a bar magnet this distance coincides with the length of the magnet; in a horseshoe it does not by any means (*see* Fig. 1). But what-

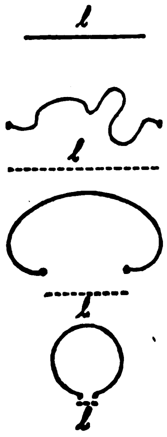

FIG. 1.—Various shapes of simple magnets, and corresponding values of l.

ever the shape of the magnet, l means just the distance between its poles. If the magnet forms a closed curve the value of l is zero, and such a magnet has no moment, though it may be intensely magnetised. If a magnet is bent so that its poles are very near together, l is just the width of the air-gap which separates them.

Now an ordinary magnet has no well-defined poles; or rather, it consists of a bundle of simple magnets, and has a multitude of them. The better and more permeable the steel or iron of which the magnet is made, the nearer will its poles lie to its ends; at least, in the case of a nearly closed horseshoe. For a line has to choose between going through a considerable length of air and going through a rather greater length of iron and then across a short gap of air. With hard steel many lines choose the former course; with soft iron most choose the latter (Fig. 2). Hence it may be said that re-curved electro-magnets approximate more closely to ideal simple magnets than do permanent ones, and the better the iron the more nearly do the lines all go across the shortest air-gap and take no longer path.

Now a dynamo field-magnet ought to form a very nearly closed circuit—at least, when the iron of the armature is taken into account. Hence we shall not be far wrong, and at any

* For Article 28, see *The Electrician*, July 31, 1885.

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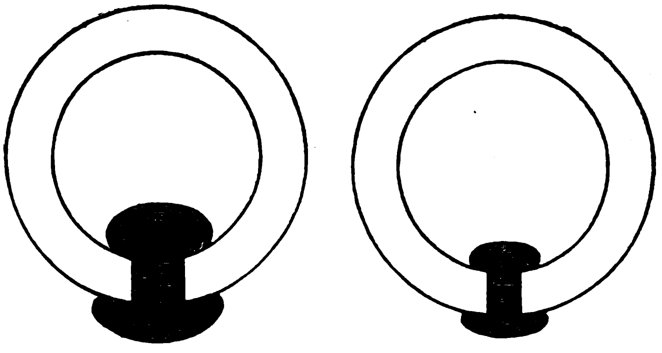
rate we shall be considering the case of greatest perfection, by reckoning l as the total air-gap, *i.e.*, the total width of air which the lines have to cross. It is ordinarily in two halves, one on each side of the armature.

One more thing we have to remember from past work, viz., the magnetic moment of a circuit conveying a current. The area of circuit being A, the number of turns of wire n, and the current C, the moment of a circuit is nAC.

Fig. 2.



Steel magnet. Very soft iron magnet.

This supposes the circuit to contain no iron; if there is iron in it its moment is much more, because of the extra lines induced in, or provided by, the iron. But there are two ways of considering the behaviour of iron in a helix. The more complete way is to take it as introducing a large number of additional lines and adding them to the lines caused directly by the current. A simple way however, which is easily applicable to horseshoe magnets, is to consider the iron only as a nearly infinitely permeable or transparent medium to lines of force, through which lines of force travel almost without resistance; so that the introduction of a bar of iron into a long series of coils welds them altogether as it were into one, and virtually enables us to crowd a great number of windings upon a given small space.

In a dynamo the thing upon which we wish to crowd lines is the armature. One way is to wind the magnetising wire directly over it; but instead of doing this (though this may be advisable sometimes) we can apply a great deal more wire by coiling it upon a large iron bar, the iron being chosen so soft as to offer a barely perceptible resistance to magnetism, and thus to make even the most distant coils nearly as effective as if they were close to the armature.

The softer the iron the more nearly will this be true, and the longer may a magnet be made with impunity. Hard iron magnets must be dumpy. Perfect iron magnets may be any length.

But then it is to be remembered that magnetic capacity of all iron is limited—it tends to become saturated when very strong currents are sent round it. This, therefore, makes a limit to the length of field-magnets beyond which it is not wise to go.

Magnets which are to be saturated should be fairly short. Magnets intended to work far short of saturation may be long.

The iron inside the armature is to be as perfectly soft as the rest—it cannot be too permeable to magnetism, any more than the field-magnet iron can be.

If the iron be all perfect the whole magnetic obstruction is the air-gaps. The best iron may be taken as 1,000, or even 2,000, times as permeable as air. Suppose it μ times as permeable, and that its length altogether is μ times the sum of the air-gaps, then its resistance and that of the air are equal, and l may in that case be considered as twice the air-gap.

Remember, as part of the air-gap we must consider any ill joint, as between the legs of the magnet and its cross piece. Any such flaw throttles the magnetic circuit considerably. All the iron should be of sufficient area, and well jointed together.

Let the sum of the air gaps be a centimetres, the total length of iron in field-magnet be i centimetres, and let its quality be such that it is μ times as permeable as air is. Then, if μ is large and a small, the effective value of the quantity l is

$$l = a + \frac{i}{\mu} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now put together the equations so far recalled, viz.:—

$$N = 4\pi m \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$
$$M = ml \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$
$$M = nAC \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and combine them algebraically.

The result is

$$N = \frac{4\pi nCA}{l} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

and this is the expression we want.

It gives us the whole number of lines of force which the field-magnet produces, and tells us that it is 4π times the ampere-turns, multiplied by the cross sectional area of the magnet, and divided by the air-gap; or by the air-gap plus an allowance for the iron, according to equation (1).

Suppose, however, the whole circuit is not of uniform area, but is throttled in some part, what value are we to give to A? Well we ought to take a kind of average, but a throttle is so important a defect that it is safer to consider that we must take for A the minimum area through which the lines have to pass. This may be in the legs of the magnet, and in some respects *should* be there, because it enables a given length of wire to make more turns.

The minimum area or throttle, again, may occur in the cross-piece of the magnet, and here it certainly should *not* be; if anything can be free and open, this can.

It may occur in the armature, and often does:—not in Edison's with the iron discs, but in Gramme's and Siemens' whose ring of iron is not very thick, it is possible for the throttle to occur in the armature. Siemens, indeed, has his field-magnet iron so thin that the armature is probably always big enough for it; but in a Gramme the cross section of the ring is commonly the smallest part of the iron circuit. In Mather and Platt's recent form this point is much better attended to than in some of the older forms. Of course there is a *double* cross section available in all forms of ring armature.

The worst possible place for the throttle to occur is in the air; but this very seldom happens. All field-magnets have pole-pieces to curve round the armature sufficiently to enlarge the breadth of the air-gap very considerably; and it is well that it is so. In fact, if sufficient area be allowed, the retardation of the air becomes diminished, and formula (1), which supposes the area of iron and air section to be much the same, becomes modified, and something like this:

$$\frac{l}{A} = \frac{l_1}{A_1} + \frac{l_2}{\mu A_2};$$

where l_1 is the width and A_1 the sectional area of the air-gap; l_2 the length and A_2 the mean area of the iron.

But it is scarcely worth while to take note of this small improvement in the formula, though it is very necessary to attend to it in construction.

The simplest and safest rule is to reckon A wherever the magnetic circuit is narrowest, and then apply the formula

$$N = \frac{4\pi n AC}{l}$$

to determine the lines of force; or $\frac{N}{A} = \frac{4\pi nC}{l}$ to find the intensity of field in which the armature revolves.

This latter quantity, 4π times the ampere-turns divided by the air-gap, may be inserted as intensity of field, instead of H, in previously obtained expressions for the E.M.F. induced in a revolving armature.

But one thing we have not yet taken into account: we have supposed the iron infinitely or very highly permeable to magnetism. So it is until it is nearly saturated. We have not taken approach to *saturation* into account.

The customary way of allowing for this is to divide the previous expression by $a + bC$, a linear function of the current passing round it. The constant a in this formula may be con-

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sidered as nearly unity; the constant b is very small in comparison, and accordingly the term bC only comes into prominence when a magnetising current, or rather the ampere-turns (*i.e.* the current multiplied by the whole number of coils of wire on the magnet), is great. This mode of allowing for saturation can be partially justified by theory, but its best justification is that it accords with experiment. The value of b must be determined for each magnet.

We can now write the expression for the number of lines of force passing through an armature, where C is the magnetising current in the field-magnet coils

$$N = \frac{4\pi n C A}{l(1 + bC)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

ECHOES FROM THE WEST-END.

Ominous rumours are reaching us from Bond street. For months past the public have been looking with expectancy to the completion of a scheme for the distribution of electricity from a central station inaugurated in this district by Sir Coutts Lindsay and Co., but from all accounts an unqualified success relative thereto cannot as yet be chronicled. In a parallel system of lighting on a large scale the cost of the conductors becomes prohibitive, and two other systems, which have each had a public trial, have been devised for the purpose of enabling electricity to be distributed over a large area without incurring in the cost of conductors such a large initial expense. The first of these is the distribution of electricity by the aid of secondary batteries, where the batteries are arranged in local groups charged up by a small current of high potential in series, and discharged in parallel; the second is distribution by transformers, where an alternating current of high potential is employed to excite induction apparatus placed in series or in parallel, the lamps being lit from the secondary coils of the apparatus. The former system possesses, probably among several disadvantages, the advantage of storing electrical energy, and of thus providing against a breakdown in the charging machinery, while the latter enjoys immunity from risks of breakdown due to the absence of liquid conductors in any part of the circuit. The secondary generators, or transformers as they are now more scientifically termed, employed in the Grosvenor district supply are those of Gaulard and Gibbs; and their plan consists in placing the transformers in series over a considerable area, one or more being situated in each establishment to be supplied with light. Each transformer consists of two columns, on which are wound the primary and secondary helices interlaced together, the primary coils of all the apparatus being connected in series and having flowing through them the alternating current supplied from the central station, the secondary coils being employed to light the lamps in parallel.

It will be observed that the great advantage of this system lies in the fact that a small current of high potential can be transformed where required into a current of lower potential suitable for incandescence or arc lamps. If the potential of the primary current is 2,000 volts and the potential of the lamps 100 volts, the value of the system as a means of electrical distribution can be expressed as $\frac{2{,}000}{100} = 20$, where 20 may be called the coefficient of transformation, a value which is important when we consider that within limits the cost of supplying and erecting the mains may be regarded as inversely proportional to this coefficient. Why we lay particular emphasis on this point will be seen presently.

It is only during the last few months that the transformers of Messrs. Gaulard and Gibbs have been constructed on scientific principles. Formerly the two columns of the transformer were magnetically separated from each other, the two straight cores of soft iron wire being simply mounted on a stand with their corresponding helices wrapped round them. Now, however, the pairs of cores are connected together top and bottom, the iron part of the transformer forming a complete magnetic circuit, and having the helices wound on the two vertical sides of the rectangle thus formed. We understand that the dangerous practice of interlacing the primary and secondary helices is still adhered to, although we see no reason why any advantage should be gained from so doing. Where the transformer is of the shape adopted by Messrs. Gaulard and Gibbs we consider that the helices ought to be kept quite apart from each other, the primary being wound on one of the vertical sides and the secondary on the other. This would entirely remove the existing danger of one coil short-circuiting on to the other, and in case of accident the work of removing a faulty coil would be that of a few minutes, whereas now, due to the interlacing of the coils, the whole must be disconnected and taken to pieces before repair can be effected. We see no theoretical objections to the adoption of the plan suggested, and we should like to hear of a trial being made in this direction, as, even in the event of a trifling loss, the immunity from the danger to which we alluded is worth some sacrifice.

But, if report says truly, it is the question of regulation which has hitherto baffled the electricians at Bond-street. The lamps are connected to the transformers in parallel, and as they are turned off the potential rises, to the imminent danger of the remaining lamps, the results of the increase of potential being, in many cases we have heard of, most disastrous. Various have been the devices tried to remedy this evil, but, so far as we can learn, without success hitherto; and, with a view to trying another transformer of his own design, we understand that Mr. Ferranti has lately been placed in charge of the Bond-street station. The designer of the new transformer requires, or rather advocates, a parallel system of primary conductors, but if our information is correct, and if the company contemplate such a change as is implied in the substitution of a parallel for a series system, it is a change of programme with a vengeance. It seems to us that with parallel conductors the transformer system for general distribution is robbed of the very advantage which makes it of value, since by this modification the coefficient of transformation is at once brought down to $\frac{200}{100} = 2$. The limit 200 being the E.M.F. which can, by the Board of Trade regulations, be allowed between two points in a building. It is surely not proposed for one moment to work a parallel system where the primary has a difference of potential of 2,000 volts. Not only are the risks of breakdown increased with parallel connections, but the briefest examination shows the proposal to be so absurd that we hesitate to believe it has ever been made. We are not in possession of all particulars relating to the new transformer, but from the description given to us it differs in no essential point from that of Gaulard and Gibbs. What can be done with the former can be done with the latter, and the solution of the regulation question seems to reside in the mode of coupling up the apparatus. We have no exact information on the point, but it appears to us that for a series system to be successful the lamps must be coupled in series from the secondary coils, while for a parallel system it is requisite that the lamps be coupled in parallel.

We trust that whatever method be employed to effect the purpose in view we shall soon silence those muttered curses against the electric light so often heard in Bond-street. It would do much to reassure the West End public if the system could be now declared perfectly successful, and we trust that ere long we shall be able to chronicle a triumph which will do credit to all concerned.

A CHARGE INDICATOR FOR STORAGE CELLS.

The Elwell-Parker secondary battery gauge, or charge indicator, is for automatically closing the charging circuit when the cells are exhausted, and breaking it when they are fully charged; also for continously showing the condition of the charge and signalling it by a bell or otherwise.

Prof. Forbes, at the Society of Arts, drew attention to the necessity for a reliable indicator, actuated by the change in density of the liquids for automatically working a switch, and he was not aware that any such was in use. The

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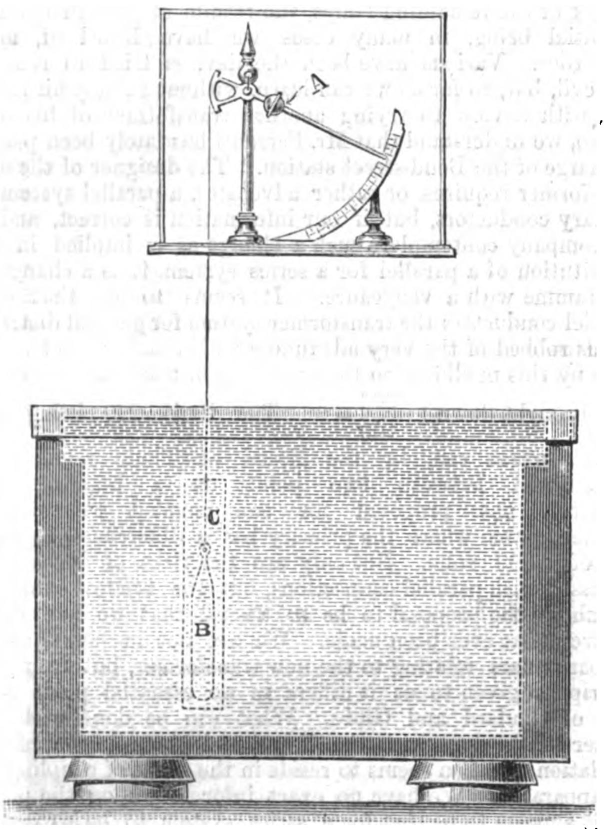
following description of the apparatus used by Elwell-Parker (Limited) may consequently be of interest:—The instrument is designed upon the principle of the hydrostatic balance and is patented by Mr. Thomas Parker. It has been used in connection with the Elwell-Parker accumulators during the past two years with perfect success. It is unaffected by the level of the solution, and does not require a special cell.

It consists of a vertical brass pillar from which projects a horizontal arm, carrying by two silk cords the beam, at one end of which is the segment of a wheel, the axis of the beam forming the centre, and at the other end is an ivory pointer and an adjustable balance weight. A glass bulb, B, hermetically sealed, and loaded so as to *just* sink in the solution when at its greatest density, is suspended in the centre of the cell by a platinum wire attached within the gauge case to a silk cord hanging from the segment on the beam. The gauge, entirely enclosed in a glass case, is placed upon a shelf directly above the cell, so that the glass bulb hangs in the solution without touching the plates.



The Elwell-Parker Secondary Battery Gauge.

It will be at once seen that, as the battery is being charged and the specific gravity of the solution increases, the bulb B will rise and the angle formed by the arm bearing the balance weight A with the vertical pillar will become more acute until the pointer reaches the bottom of the scale, when a cross bar formed by a fine piece of platinum wire at the end of the pointer comes into contact with two upright platinum terminals, and so closes the circuit either of an electro-magnet switch (for automatically cutting the battery out of the general charging circuit) or of an electric bell in the engine house (to show that the charging is complete), or where a gas engine is used to cut off the gas and so stop the engine. A similar contact may be made when the cells are exhausted (to any desired extent), and the charging circuit thrown in again, or a bell sounded by the pointer reaching the top of the scale.

As the capacity of a secondary battery, when always discharged in series, depends upon that of the weakest cell it contains, and as every cell will require exactly the same amount of current to recharge it, a single indicator placed over any cell is all that is required.

DYNAMO TESTS.

(Continued from page 315.)

From the preceding table and the dynamometer record, we get the following data:—

Mean reading scale beam	655·9195
Mean friction reading	13·72
Corrected reading	642·1995
No. revolutions	106·180
Foot pounds absorbed............	225585395·

Heat units passing through cal. (uncorrected)	157735·96
Heat units radiated from calorimeter ....+	4045·89
Correction to reduce ther. to abs. temp. .... –	169·63
Stem correction ....+	647·12
Total heat units..............................	162169·34

Mechanical equivalent for 1° C. ... 1391·05 foot pounds.
Mechanical equivalent for 1° F. ... 772·81 foot pounds.

In this method the uncertainty due to the specific heat of the iron and its temperature is avoided. The greatest possibilities of error are in the mean temperature of the calorimeter and the stem correction. It is probable that too great a value of the latter has been taken; for the thermometers were in the water for several hours, and a considerable portion of the stem must have been heated by conduction.

The co-efficient of radiation was taken from the first experiment.

The results of the experiment are:—

First method mech. equiv. = 768·3 + an indeterminate correction.

Second method mech. equiv. = 772·81.

It would seem, then, that within the limit of error of these experiments, the dynamometer is correct, and, considering the probable accuracy of the last method, there seems little doubt that the work calculated from the dynamometer readings is as accurate as the adjustments of the machine and the readings themselves.

TESTS.

For the full load tests, the machines were run at least ten hours before any measurements were made. They were then tested at intervals of from one to two hours.

For the partial loads, the dynamos were run on quarter load for two or three hours, then tested, then run on half load for a couple of hours, and tested, &c.

The method of making a test was as follows:—A time to begin was set, and the observers got ready to start at the signal from the test house. After the signal, double readings of the potential and current galvanometers were simultaneously made each minute, and the scale beam and number of revolutions of the dynamometer observed. The field galvanometer was reversed, and read as often as possible, usually four or five double readings.

At the end of ten minutes a signal to stop was made; the dynamo was stopped, the field circuit broken, the storage battery put on, and the armature resistance measured. The brushes were then lifted, and the field circuit made and its resistance measured. Finally, the constants of the current and potential galvanometers were checked on the German silver strips.

When the tests for the day were finished, the friction of the armature and of the dynamometer was obtained, and the latter subtracted from the power applied for each test.

Communication from the test house to the dynamo shed was by an electric bell, and through a speaking tube.

The following notation will be used in the formulæ:—

- e difference of potential between terminals of dynamo;
- E total electromotive force generated in armature;
- i current in external circuit;
- i_s current in field;
- R resistance of external circuit;
- r_a resistance of armature coils;
- r_s resistance of field with box for adjustment;
- S resistance of field alone;

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W energy applied in horse-power;
W_t total electrical energy in horse-power;
W_e energy in external circuit in horse-power;
W_a energy in armature in horse-power;
W_s energy in field in horse-power;
Ef_t total efficiency of electrical conversion;
Ef_c useful commercial efficiency;
η $= Ef_c / Ef_t$;
p_a percentage of power used in armature;
p_s percentage of power used in field;
n number of revolutions per minute;
Fric. friction of armature;
t_a temperature of the air in degrees centigrade;
t_p temperature of pole-piece in degrees centigrade;

Of these, e, i, i_s, r_a, S, W, n, t_a and t_p, were observed directly.

E was calculated from $E = e + (i + i_s)\, r_a$;

R was obtained from $R = e / i$;

r_s was from $r_s = e / i_s$; it was also checked by observation after each test.

The other formulæ used were—

$$W_t = \frac{(i + i_s)\, e + (i + i_s)^2 r_a}{745 \cdot 3}$$

$$W_e = \frac{i\, e}{745 \cdot 3}$$

$$W_a = \frac{(i + i_s)^2 r_a}{745 \cdot 3}$$

$$W_s = \frac{i_s\, e}{745 \cdot 3}$$

$$Ef_t = \frac{W_t}{W}$$

$$Ef_c = \frac{W_e}{W}$$

$$\eta = \frac{Ef_c}{Ef_t}$$

$$p_a = \frac{W_a}{W}$$

$$p_s = \frac{W_s}{W}$$

EDISON NO. 5 DYNAMO.

This was the first machine tested, and the measurements were intended as much to show any weak points in the method as to serve as a test of the dynamo. If no trouble occurred, the work was to be accepted, otherwise it would have been repeated after the causes of error had been removed.

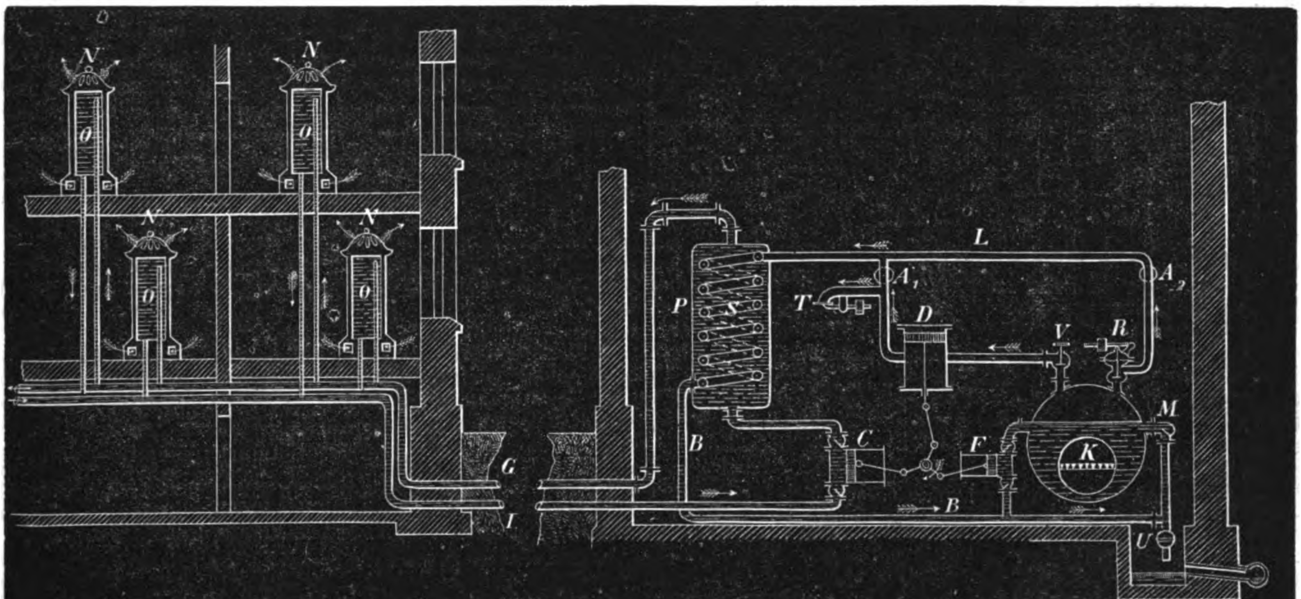
Diameter of armature	$7\frac{1}{16}$in. inner; $7\frac{7}{8}$in. outer.
Weight of machine	2475 pounds.
Number of commutator bars	50
Turns of wire in a coil	2
Length of useful wire in a coil	52in.
Brushes adjusted or not?	Yes.
Diameter of bearing	$1\frac{5}{16}$in.
Length of bearing	$5\frac{5}{8}$in.
Revolutions per minute	1400
Volts for best work.........................	125
Amperes for best work	100

RESULTS OF MEASUREMENTS.

Date.........................	May 29th.		
Time.	12·40	1 40	3·00
Load	Full.	Full.	Insulation of armature gave way.
E.M.F. at terminals....	125·2	121·59	
Total E.M.F.............	131·5	128 00	
Current in ext. cir.	100·92	98·06	
Current in field	2·385	2·296	
External resistance.....	1·241d	1·240d	
Armature resistance ...	·0613	·0638	
Field, with box	52·59	53·08	
Field, alone..............	...	...	
Power applied...........	18·89	18·05	
Total elect. energy.....	18·23	17·24	
Ext. elect. energy......	16·95	16·00	
Energy in arm.	·878	·863	
Energy in field	·401	·374	
Total efficiency	96·53	95·49	
Commercial efficiency .	89·76	88 63	
Economic coefficient...	92·99	92·82	
% power in arm.........	4·65	4·78	
% power in field	2·12	2·08	
No. revolutions	1400·8	1389·7	
Friction of arm..........	...	...	
Temp. of air	26·4° C.	27·[illegible] C.	
Temp. of pole-piece....	44·° C.	45·4° C.	

(To be continued.)

RECK'S SYSTEM OF COMBINED ELECTRIC LIGHTING AND HEATING.



The electric light often gives much disappointment from an economical point of view, which cannot be wondered at when it is borne in mind that this light is often recommended for places not at all suitable for its use. The future of the electric light would no doubt be better secured if it were introduced in places where a favourable economical result could safely be depended upon. Particularly would this be the case in a building heated by steam from a heating apparatus constructed to make use of the exhaust steam from the steam motor of a dynamo machine supplying electricity to the electric

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lamps in the building. The requirements for heat and light being almost equal during the same part of the year, a building would, by an arrangement as the one above-mentioned, be heated and at the same time lighted by electricity at a very small cost. The reason why this profitable combination of electric lighting and heating of a building by exhaust steam has not yet been generally adopted must be looked for in the fact that the direct application of exhaust steam for heating purposes, by circulating the steam itself through pipes placed about the building, is defective in two essential ways. Firstly, exhaust steam cannot profitably be carried far from the boiler, partly because the large pipes required by the exhaust steam are expensive, and partly on account of the great waste of heat at places situated outside the localities to be heated. Then most heat is generally required at a time, viz., the morning, when no light is required; and when an effective light is wanted there is often no use for all the heat contained in the exhaust steam. These defects are done away with by the indirect heating by exhaust steam, as proposed by Mr. Reck. The figure shows an arrangement by which Mr. Reck proposes to store heat from the exhaust steam by employing it to heat a reservoir of hot water. K is the boiler; R a reducing valve supplying the necessary steam from the boiler when more steam is required than can be got from the engine; T is a safety-valve letting out the surplus of exhaust steam if the engine supply more than required for heating; A_1, A_2, and V are common stop-valves. The exhaust steam passes from the cylinder D to the coil of pipes S, by means of which its heat is transferred to the water in the tank P; and by means of a pump C this water is kept circulating from the tank P through the pipe G to the heating-coils O in the building, from which it again returns through the pipe I to the tank P. F is the feed-pump. The dynamo machine which supplies the electric current to the lamps is not shown in the wood-cut. By an arrangement of this description the electric light might be obtained in a country house at a comparatively small cost.

Messrs. Capito and Hardt, of Queen Anne's Gate, Westminster, are the agents for Mr. Reck's system.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

The resumption of the discussion on the President's inaugural paper took place on Thursday evening, 25th February, at the Institution of Civil Engineers. Prof. Hughes, F.R.S., again withdrew from the chair, which was taken by the late president, Mr. Spagnoletti, who announced that Mr. F. H. Webb, the secretary, had been appointed editor of the Society's *Journal*, Prof. Ayrton having retired from that position.

Mr. W. H. Preece, F.R.S., then continued the discussion adjourned from the previous meeting, speaking in eulogistic terms of Prof. Hughes's investigations, which, he said, threw considerable light on many obscure problems that had perplexed and hindered electrical engineers from the very first. Self-induction had always been the *bête noir* of practical telegraphists, and the necessity for getting rid of it grew more urgent as greater needs arose for increasing the speed of telegraphic signalling. He had himself worked experimentally with this object in view a good while ago; and as far back as 1877 he had read before this Society a paper bearing the title "On Shunts," which had a close relation to the subject now under discussion, but which was eclipsed at the time by the sudden appearance of the telephone, and had since been lost sight of. That paper gave the results of a lengthened investigation into the properties and behaviour of self-induction, due to electrostatic and electro-magnetic causes. As to the latter, he described it as being similar in effect to inertia in dynamics, and since that date the phenomena have been commonly spoken of as due to electro-magnetic inertia. Electricity is a form of energy, and when an electric current passes along a conductor where another conductor is in the magnetic field of that current, energy is set up in the latter at the expense of the magnetic field itself. Certain French experimenters had drawn attention to the fact now explained by the President that the speed of the current differed in iron and copper; and an Italian scientist had pointed out a difference also in respect to the different speed at which the current travelled when steady and when intermittent. But he (Mr. Preece) had devoted his experiments chiefly to apparatus employed for telegraphic purposes. At that time there was no more delicate form of indicator than the reflecting galvanometer, nothing nearly approaching the sensibility of Prof. Hughes's appliances being then even imagined. But with the means at his disposal he made some curious discoveries, which had proved extensively useful in the sphere of practical telegraphy. Explaining diagramatically the method pursued, Mr. Preece showed that by taking the self-inductive effect of one coil of an electro-magnet as a standard of unit, the result of adding a second coil in series was to increase the effect 17 fold; by adding a piece of iron across the bottom poles of the two coils the effect was increased by 496, and by the addition of a similar piece on the top the increase was 2,238. The bearing of these facts on the construction of Relays became evident when it was found that by cutting these two pieces of iron in half at top and bottom the effects of self-induction were enormously diminished. It was also noticed that they were reduced at least one-fourth when the coils were joined in quantity. The Relays then commonly in use varied immensely in their practical usefulness, though their construction and plan appeared faultless. After these experiments, however, they were able to construct apparatus of this class which admitted of vastly increased speed of working. More recently the galvanometer had been cut out at the suggestion of a Bristol telegraphist, who noticed that "sparking" was got rid of when that portion of the apparatus was dispensed with. As regards telephone working, the chief difficulty was overcome by doubling the wire, and Prof. Hughes had now shown that twisting it was even more efficacious. Some very costly experiments had been made by the Post Office to test the possibilities of of long distance telephony between London, Liverpool, and Manchester. The wires were of iron, however, and failed. If they had been of copper, possibly the experiment might have succeeded. The question of stranded iron wire was not likely to materially alter the existing arrangements, for a stranded wire affords the best lodgment for snow, as was found during the recent storms, when lines of that description were the very first to succumb. They are not so durable, and on other grounds it is unlikely they will be preferred to copper. Amongst other means that had been devised for curing lines of self-induction, the speaker described that in which the Relay is connected to earth through a condenser, and "bridged" by a balancing resistance, the adjusting being so managed that the current from the condenser cuts off or neutralises the effect of line induction. In conclusion, Mr. Preece contrasted the laborious and expensive trials undertaken by his department and the decisive results obtained by the simple but marvellously sensitive instrument before them, guided by the genius and unerring instinct of its inventor, Prof. Hughes.

Dr. Fleming spoke at some length with reference to the bearing of the experiments on the time constant of a magnetic coil, and their value in determining the coefficient of its self-induction. In venturing to explain some of the phenomena appearing on stranded wires, he pointed out that by cutting the circle of a conductor, giving it a serrated edge, which is the practical outcome of stranding, the magnetic permeability is interrupted and its self-inductive properties greatly reduced. If we could manufacture a serrated wire by, say, drawing it through a die, giving it a section like that of a pinion wire, the effect would in all likelihood be the same. Expressing his high appreciation of the President's labours, Dr. Fleming respectfully suggested that as a term is wanted to express the unit of self-induction no more fitting or appropriate designation could be found for it than the "Hughes."

Mr. Desmond FitzGerald drew attention to his paper on the electric polarity of a current, published in 1870. He pointed out that between the inlet of the current and its manifestation on the conductor there is an appreciable interval; and that it is in this interval that the birth of electro-magnetism takes place, the magnetic effects preceding in reality the actual passage of the electric current. But the subject would require too much time to do justice to it in a brief speech, and he would reserve his observations for a more favourable opportunity.

Prof. Silvanus Thompson, while endorsing everything that had been said in admiration of Prof. Hughes's beautiful experiments, thought we ought to be careful to take into account the rate of variation in the current manipulated under the intermitting clockwork of this apparatus; and to ask him particularly whether any difference were noticeable in the results when a high speed and when a low speed respectively was employed. He, himself, would have preferred some definite number of vibrations, say those of a particular musical note. He illustrated the importance of this consideration in relation to what have been called the spurious resistances in alternate current dynamo machines as well as in telephonic working. He questioned the accuracy of Prof. Forbes's explanation offered at the last meeting, and pointed out that the pinion or stranded pattern would possess no advantage in the case of copper wire. For telephone circuits, he was clearly of opinion that iron wire should never be used, and stated that three years back he had advocated the employment of silicate bronze.

Prof. Ayrton, after some observations on what had fallen from the previous speaker, confessed that, although he could not concur

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in the view that theory and mathematics always came after experiment and practice, he had latterly been led to the conclusion that there were certain phenomena of nature which mathematical calculations could not reach or explain.

Prof. HUGHES, having only time to say a few words, it being then after ten o'clock, promised to commit his observations to writing for publication in the Society's *Journal*. But, in reply to Prof. Thompson, he stated that at all speeds within the limits of the interrupter no difference of results had been observed.

The CHAIRMAN, in closing the proceedings, announced that the Society would be glad to receive communications on the subject from any gentlemen who had wished, but had been unable, to join in the discussion.

PHYSICAL SOCIETY.—February 27th.

Dr. J. H. GLADSTONE in the chair.

Dr. Sydney Young and Mr. D. E. Jones were elected members of the Society.

The following communications were read:—

"The Relations of Pressure, Temperature, and Volume in Saturated Vapours," by Prof. W. C. UNWIN. In the first part of this paper certain formulæ given by Messrs. Ramsey and Young in a recent communication on "Some Thermodynamical Relations" are criticised. The most important of these is the statement that for different saturated vapours at the same pressure $p\frac{dp}{dt}$ is constant. Prof. Unwin finds, however, that $t\frac{dp}{dt}$ is less constant than $t^2\frac{dp}{dt}$, while $\frac{t^2}{p}\frac{dp}{dt}$ is nearly a constant quantity for all saturated vapours under any conditions. This result suggested that $\frac{t^{n+1}}{p}\frac{dp}{dt}$ might be more nearly constant, and the integration of this gives

$$\log. p = a - \frac{b}{t^n}$$

a formula to the examination of which the second part of the paper is devoted. From it may be derived the following relations, in which for convenience in calculation the logarithms given are to the base 10.

$$t = \left(\frac{b}{a - \log p}\right)^{\frac{1}{n}}$$

$$\frac{1}{p} \cdot \frac{dp}{dt} = 2{\cdot}3025\,\frac{nb}{t^{n+1}}$$

$$= 2{\cdot}3025\,n\,\frac{(a - \log p)^{\frac{n+1}{n}}}{b^{\frac{1}{n}}}$$

$$\frac{t}{p} \cdot \frac{dp}{dt} = 2{\cdot}3025\frac{nb}{t^n}, \text{ \&c.}$$

These formulæ have been examined in the case of steam from 30° to 230° C., and with pressures varying from ·4 to 20 000 mm. The constants were found to be

$a = 7{\cdot}5030$ $b = 7579$ $n = 1{\cdot}25$

and the differences between the calculated results and the observations of Regnault and Zeuner rarely exceeded 1 per cent., while generally much smaller.

a, *b*, and *n* have also been found for some other substances, with the following results:—

Alcohol.................	$a = 7{\cdot}448$	$b = 8784$	$n = 1{\cdot}29$
Ether	$a = 6{\cdot}9968$	$b = 3047$	$n = 1{\cdot}153$
Mercury	$a = 9{\cdot}8651$	$b = 597{\cdot}5$	$n = {\cdot}69$
Carbonic acid	$a = 8{\cdot}4625$	$b = 302{\cdot}8$	$n = {\cdot}77$

Prof. PERRY offered some criticisms upon this paper, and believed that for practical purposes the expressions given would not be found superior to Rankine's formula

$$\log p = a - \frac{b}{t} - \frac{c}{t^2}$$

which gives p in terms of t, and a quadratic expression for obtaining it in terms of p. He also observed that the chief aim of Ramsay and Young's paper was to obtain relations between the pressure and temperature of different saturated vapours, so that the connection between temperature and pressure having been observed and recorded for one vapour, that for any other vapour could be at once deduced from it.

"On a Map of the World, in which the Proportion of Areas is Preserved," by Mr. WALTER BAILEY. The author had devised a method for constructing such a map, but has subsequently found that one precisely similar was employed by Flamsted in 1729 for charting the stars in his "Atlas Celestris." The construction applied to the earth as briefly as follows:—Draw a straight line to represent the meridian that is to occupy the centre of the map. Divide this line into equal parts, representing upon a convenient scale the distance between the parallels of latitude, and through these points draw a series of lines at right angles to the original line; these are the parallels of latitude. Mark off on these the actual distances at which the meridians cut them; through the points so found the meridians may be filled in and the map constructed. From the method of construction it is evident that although the outlines in the map are distorted, the amount of distortion increasing with the distance from the central meridian, the proportionality of areas is preserved, a fact which the author believes will render the map useful for recording rain-fall, depth of sea, ocean currents, &c.

"On a Delicate Calorimetric Thermometer," by Prof. S. U. PICKERING.

COMPANIES' MEETINGS.

Telegraph Construction and Maintenance Company (Limited).

The twenty-second ordinary general meeting of the members of this Company was held at the offices, 38, Old Broad-street, E.C., on the 2nd inst., Mr. Philip Rawson, J.P., presiding.

The MANAGER (Mr. William Shuter) read the notice convening the meeting and the minutes of the last ordinary and half-yearly general meetings, which were signed as correct by the Chairman. The report of the Directors was taken as read.

The CHAIRMAN: Gentlemen, I am sure you will regret quite as much as I that our worthy Chairman is not present to day, but about an hour ago we received a note from him to the effect that his doctor would not allow him to go out in this inclement weather. We have no reason to believe that he is seriously indisposed, but you all know how very trying the weather has been, and as a matter of prudence his medical adviser has counselled him to keep at home. I may mention as an interesting fact that Sir Daniel Gooch has presided at 45 consecutive meetings of the Company, and this is the first meeting which circumstances compel him to be absent from. I regret his absence all the more as I am called upon to preside at this meeting at very short notice indeed. I myself have been confined to the house for three weeks, and I feel that I may very fairly call upon you for your indulgence. However, it is always pleasanter, or, rather, it is a much easier task, to preside at any meeting where the company is prosperous, and I think I may fairly say that our Company has been very prosperous, and I can sincerely congratulate you. The report and the figures are drawn exactly upon the same lines as you have been accustomed to receive them, and there is very little for me to say. The accounts, as you perceive, show a net profit of £82,740, and adding the £72,166 brought forward there is a total of £154,907 to be dealt with. That enables us to declare the usual dividend of £1. 16s. a share for the half year, making with the interim dividend 20 per cent. for the whole year, and to carry over the very substantial sum of £65,267. To pass on to the next paragraph—the operations carried out in 1885—I think it has been mentioned, and is within your knowledge, that early in the year the Government entered into a contract with this Company for the manufacture of 1,000 miles of cable. The cable was manufactured and completed in May, and has been paid for. At the same time the Company manufactured 322 miles of cable, which they laid from Shanghai to Port Hamilton, the new coaling station off the coast of Korea. That cable was successfully laid, and we have received the money for it. We also manufactured 740 miles of cable for the Eastern and South African Cable Company, which we laid in August as a duplicate line between Zanzibar and Mozambique. It has been covered with the new brass tape, which is a perfect protection against the teredo, the little insect which has been so very destructive to cables in some parts of the world. The Heligoland-Cuxhaven cable was partially relaid and put in good working order. That was a small matter. The next two points in the report refer to the cable which has been laid to the Fastnet Rock from Crookhaven; and to the cable connecting the "Sunk" Lightship from Walton-on-the-Naze having been successfully maintained, with but slight interruption. Those were experiments, and particularly as regards the "Sunk" Lightship. We had great difficulty at first in keeping up the communication, but our electricians and engineers have, I believe, now got quite over the difficulty; and at the date of this report the "Sunk" Lightship connection had been maintained for 306 out of 311 days. There are also various lengths of cable, amounting to 763 miles, which we have manufactured for different telegraph companies and colonial Governments. The steamships "Calabria" and "Kangaroo," which were chartered by the Government for a long time in the Red Sea, have now been discharged, and are both in the Thames. I do not think there is anything else in the report which calls for further remark. I may mention, with reference to future work, that we are manufacturing a cable 550 miles long for the Eastern Extension Company, to be laid between Singapore and Penang. There is also a considerable contract with the African Direct Cable Co. for 2,000 miles of cable. The contract itself is all completed, and is only awaiting signature until the subsidy, of which you have no doubt read a good deal in the papers, is confirmed by Parliament. We have also one or two other small matters in hand which, however, I need hardly allude to. I have much pleasure in moving this resolution:—"That the report and accounts of the Directors to the 31st December, 1885, submitted to this meeting be, and the same are hereby, received and adopted, and that a dividend of 36s. per share, in addition to the 12s. a share interest, or interim dividend, paid to June 30, 1885, be paid upon all the shares of the Company for the year ended December 31, 1885, and that such dividend be paid free of income tax."

Mr. GEORGE W. CAMPBELL briefly expressed his pleasure in seconding the resolution.

Mr. WM. ABBOTT said he was sure that he expressed the unanimous feeling of the shareholders when he regretted that the worthy Chairman of the Company (Sir Daniel Gooch) was indisposed. At the same time they were all aware that one of the characteristics of Sir Daniel was extreme caution, and he was extremely judicious in anything he undertook. He was very pleased to know that that cautiousness had prevented Sir Daniel Gooch from leaving home that day. There was one matter in

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connection with their affairs on which the report was silent, and as to which he would be glad if the Chairman would give them some information. He referred to the important matter of the electric light. There was no doubt that their Company held a forefront position as to cables and everything else electrical. They had capital at their back, and their officers were experienced men, of long-standing and high training; and, therefore, he wished to know why it was that electric lighting stood still. Was it that Mr. Chamberlain's Bill had completely killed this enterprise? When they heard so much about the unemployed in London, and knew that there was an enormous amount of capital seeking employment, it did seem strange that such a great enterprise as electric lighting, which was making such extraordinary strides in every country but England, should remain stationary; and he thought they ought to have some authoritative statement from the Chairman as to why it was that the report was silent on such an important matter. He had no hesitation in saying that if a comprehensive scheme were propounded which would give capitalists a chance of securing a fair return on their money for a certain number of years, any amount of capital could be obtained for the enterprise, which was so very important to the community at large. As to the Lightships, he presumed that that was a matter which was now entirely in their hands, and he foresaw that it would be a business for which there was a very large development; for not only would Lightships be connected with the Post Office telegraph system, but also all the Lighthouses. This would be a very important matter to the marine interests of this country. He had nothing further to say except to compliment the Directors on the very small amount of transfer fees, showing that they had, although a large proprietary, a thoroughly contended one.

The CHAIRMAN: Mr. Abbott has alluded to Mr. Chamberlain's Act, and I think there can be no doubt whatever that that Act has been a very great clog on the electric light enterprise. As to our own system of electric lighting, we have said nothing about it, because we have not completed our experiment. We have met with a great variety of little difficulties, all of which I believe have been removed; but our greatest difficulty has been in connection with the inhabitants surrounding the Paddington station. That is a difficulty the end of which I do not exactly know. As far as we are aware, however, the inhabitants there have been quiet for a long time; but what may happen when we get our machinery "in full swing" I cannot say. We hope the matter will be all straightforward and right, and that all difficulties will be removed. If there is no other question I will put the motion. No other shareholder rising to address the meeting, the resolution was put and carried unanimously.

On the motion of the CHAIRMAN, seconded by Vice-Admiral Sir GEORGE H. RICHARDS, C.B., F.R.S. (the Managing Director), the retiring Directors, Lord Alfred Paget and Mr. George William Campbell, were re-elected, as were also the Auditors, Mr. John Gane and Mr. James Glegg.

Mr. WILLIAM FORD then remarked that it was some years since he attended a meeting of the Company, and it was a great satisfaction to him, as he was sure it was to his co-proprietors, that it had survived some of the advice which years ago he had ventured to give them. They had to thank the Directors for having rejected much of the advice which he then offered to them, for he feared that if they had followed some of the juvenile precepts which he had ventured at the period referred to to force on their minds, the happy result announced in the report would not have been consummated. He might state that at the date in question he had been most strongly in favour of the utmost publicity in the Directors' reports—that they should communicate to the shareholders every possible tittle of information that could be given. He recanted that view as an error. Many things had happened since then. Important competitors had grown up for the manufacture of cables, and he ventured to say that the information contained in their reports too frequently gave to their competitors an insight into transactions in the business of the Company which, as competitors with them, it was exceedingly indiscreet for them to give. He ventured to say, by way of illustration of what he meant, that if he had had the preparation of the report which had been submitted to them on the present occasion, he would have omitted paragraph 3 and sub-sections A to F, and would have simply stated this: "Various important contracts have been entered into and successfully and profitably executed during the course of the year." Any further information which shareholders taking an interest in the affairs of the Company desired might doubtless be obtained by applying to their able manager, Mr. Shuter. He did not intend to make his observations the basis of a resolution for the guidance of the Directors; but it was his opinion—and he believed that the experience of the gentlemen at the Board would confirm this view—that in a manufacturing company of such a character as theirs, having powerful competitors, it was not discreet always to tell who their customers were, or what amount of work they had done for them. Indeed, in the case of private undertakings, some customers would greatly object to have the information of the business they transacted communicated to the public. There were many matters in the report of imperial importance which he thought it would have been exceedingly discreet to have omitted, but which he feared some of the shareholders, of his own previous juvenile way of thinking, would not like to have had dispensed with. What he had said was a mere prelude to a vote of thanks which he desired to propose to their able chairman, Sir Daniel Gooch, whose indisposition he exceedingly regretted, and, indeed, but that he had expected to have the pleasure of meeting Sir Daniel, he would not have been in the city that day. He desired to convey to him and the other members of the Board the high appreciation which the shareholders held of their valuable services. After the lapse of so many years it was a great pleasure to him to see that the Company still enjoyed the advantage of the very able assistance which they derived from their energetic and able manager, Mr. Shuter; and also that they still benefited by the skill and magnificent abilities (he used that expression not as a mere figure of speech, but from his knowledge of the fact) of Mr. Willoughby Smith and Mr. Clifford. He might also add the name of Captain Halpin, and of other gentlemen connected with the Company—men of the highest honour and integrity, who had served the Company well and ably. He hoped they would remain with the Company for many years, to their own profit and the profit of the shareholders. He did not believe that the Directors would consider him in any way wanting in respect to them in associating their names with the names of the other gentlemen he had mentioned. He concluded by proposing a cordial vote of thanks to the Directors, associating with the vote the names of Mr. Shuter, Mr. Willoughby Smith, Mr. Clifford, Captain Halpin, and the other officers of the Company.

Mr JOHN NEWTON seconded the motion. He thought that the shareholders had received such substantial benefit from the Directors that they might place their affairs entirely in the hands of those gentlemen. Indeed—alluding to Mr. Ford's remarks—if they simply announced the dividend to the shareholders the latter would be perfectly satisfied; but such sentiments or principles could, he maintained, only apply to a company which had given such evidence of progress as theirs had. A trading company could at all times, if it desired to do so, announce facts when they had been accomplished, retaining only such information as would be of advantage to their opponents. When, however, the Telegraph Construction and Maintenance Company obtained a contract all their opponents knew it—they would not be such fools as not to know it. The Company's work was of such a splendid character that they carried all before them.

The resolution was carried unanimously.

The CHAIRMAN: On behalf of the Directors and the other officers of the Company whom you have so highly eulogised I beg to return you sincere thanks. I am quite sure that the exertions they have used in the past will be fully at the disposal of the Company in the future, and that nothing will be wanting on their part, or on the part of any of us, to maintain the continuance of the success we have hitherto enjoyed.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	Closing Prices. March 3.		Business Done Week Ending March 3. Highest.	Lowest.
Anglo-American	83½,	84½	35¼	33¾
Do. Preferred	56½,	57½	58	56¾
Do. Deferred	10½,	11½	11½	11
Brazilian Submarine	11,	11½	11⅛	10⅞
Cuba	10½,	10¾	10⅝	10⅜
Do. Preference	17,	18	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	—	—
Direct United States Cable	9⅝,	9⅞	9¾	9⅝
Eastern Telegraph	11⅞,	12⅛	12⅛	11 15-16
Do. 6 per Cent. Preference	14,	14½	14½	14 1-16
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	13	13½	13½	13
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 1-16	6 15-16
Do. Preference	13⅜,	13⅝	13⅝	13½
Great Northern	14½,	15	15	14½
Indo-European	35,	36	35¾	35½
Reuter's	6½,	7½	6¾	—
Submarine	200,	210	205¾	204½ x.d.
West India and Panama	¾,	1	⅞	13-16
Do. 1st Preference	9½,	9¾	9¾	9
Western Brazilian	6⅞,	7⅛	7 1-16	6 15-16
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	93,	102	—	— x.d.

TELEPHONES.

Consolid. Telepho e and Maintenance	15-16,	1 1-16	—	—
Oriental	3-16,	5-16	¼	—
United Telephone	12½,	12¾	12⅝	12⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3¼,	3¾	3¼	—
Do. (fully paid)	5,	5½	—	—
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1½,	1¾	1 13-16	1⅞
Maxim-Weston	5-16,	7-16	—	—

MISCELLANEOUS.

Telegraph Construction	38½,	39½	39½	38½
India Rubber, Gutta Percha, and Telegraph Works	23,	24	24½	23 x.d.

TRAFFIC RECEIPTS FOR FEBRUARY, 1886.

COMPANIES.	Feb., 1886.	Feb., 1885.	Increase.	Decrease.
Cuba Submarine	2,750	2,730	20	—
Direct Spanish Telegraph	1,576	1,442	134	—
Eastern Extension	33,688	40,114	—	6,426
Eastern Telegraph	48,814	61,784	—	12,970

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NOTES.

Mechanical Telephones.—The Byng Telephone Company has been registered. Its capital is £5,000 in £10 shares.

Obituary.—The death is announced, in France, of M. Auguste Guérout, well known in connection with *La Lumière Electrique.*

The Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 5th inst. amounted to £3,357.

The West Coast of America Telegraph Company.—The gross earnings of this company for the month ending February 28th amounted to £3,300.

Electric Steering Gear.—The U.S. steamer "Tallapoosa" has arrived at Fortress Monroe from New York, after a successful test of her electric steering gear.

Gas in Paris.—During January last the receipts of the Parisian Gas Company were diminished 1 per cent. This was due to the growing usage of the electric light.

Canada.—The superintendent of Government telegraph lines in the Canadian North-West states that a new line will be erected between Battleford and Fort Pitt in the summer.

The American Telegraphs.—The House Committee on Post Offices and Post Roads has unanimously agreed to report adversely all Bills before it for the purchase or construction of telegraph lines by the Government.

The Telephone in Austria.—Advices from Vienna state that as a practical result of the experiments recently carried out between that town and Brünn, telephonic communication will be permanently established.

The Electric Light in France.—It is proposed to install the electric light in the Bon Marché and the Gare de l'Ouest. The Bourse and the mansions in its vicinity will also, it is thought, adopt the new light.

Earthquake Shocks in Egypt.—A telegram from Cairo states that a shock of earthquake was felt there at half-past ten o'clock on Wednesday night last week. There was another shock on Thursday morning at six o'clock.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended March 5th were £2,724, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

The Telephone in London.—At the last meeting of the Fulham Board of Guardians, an offer was considered from the United Telephone Company for laying on wires for use in the clerk's office, infirmary, workhouse, and porter's lodge, at a cost of £28 per annum. The matter was referred to committee.

The Police and the Telegraph.—Orders have been issued to all Postal Telegraph offices in the metropolis that messages are to be accepted without prepayment when tendered by officers of the police force within the Metropolitan Police district, and addressed to Scotland-yard on police business.

New Zealand.—Advices from New Zealand state that the other day the Cable Company submitted certain propositions to the Government with respect to the subsidy and tariff, which were not entertained, and the Government has cabled the Agent-General to ascertain the cost of making and laying a new cable.

Liquidation.—A petition for the winding-up of the Consolidated Electric Company has been presented to the High Court of Justice by William Morrison and Sons, of 96, Leadenhall-street, E.C., creditors of the company; and the petition is directed to be heard before Mr. Justice Pearson, on Saturday, the 13th inst.

Portugal.—The Gas and Light Company of Portugal was registered on the 16th ult., with a capital of £100,000 in £5 shares. Its object is to carry on in Portugal, the Portuguese possessions, or elsewhere, the business of gas manufacturers and electrical engineers, and every other business connected with the manufacture of gas and electricity.

The Central Station at Milan.—The central station in Milan, installed by the Société Italienne Edison, now possesses eight Edison dynamos, 1,000 16 candle-power lighters, supplying current to 7,921 lamps. On the 1st of January, 1885, the number of lamps installed did not exceed 5,530. Arc lamps to the number of 101 are also variously installed.

Post Office (24th Middlesex) Rifle Volunteers.—The following men of this corps are announced as having passed their examination in flag signalling at Aldershot last August, and as now being entitled to wear the badge:—Staff-sergeant W. R. Williams, Sergeants R. E. Kemp and T. Pusey, Corporal W. Ruckman, Privates W. Malion, L. D. Barclay, and D. G. Trolley.

Electricity and Lighthouses. — The lighthouses at present possessing installations of the arc light upon the coast of France are those of Dunkerque, Calais, Gris-nez, La Canche, La Heve, Les Baleines, and La Palmyre. A large number of lighthouses of the first order, now lighted by mineral oil, will, it is said, receive installations of the electric light at an early date.

Earthquake in Norway.—On the 1st of January a violent trembling of the earth was experienced in Central Norway, especially at Elverum and Loiten. A distinct shock was also felt on the morning of the 16th of January in the province of Christiansand. The barometer was very low at the time, but no sensible variation was observed during the continuance of the phenomenon.

Indian and Colonial Exhibition.—We understand that it has been decided to supply about 1,000 of the incandescent lamps in connection with the lighting of the forthcoming Indian and Colonial Exhibition from the Electrical Power Storage Company's accumulators. This will, we believe, be the largest number of lamps in any one building which has up to the present been supplied from storage batteries.

The Storm in the States.—The *Standard's* New York correspondent reports that the gale which swept over parts of the country recently was at the rate of eighty-four miles an hour; the greatest rate recorded of any previous gale was seventy-two miles. There was an extremely low tide on the day in question. The operations of most of the telegraph companies were stopped, many people were blown down, and there were several minor accidents.

Telegraph Clerks and Sunday Duty.—In the House of Commons last week, Mr. H. H. Fowler, answering Mr. Vincent, stated that the question of the pay of provincial telegraph clerks was carefully considered in 1881, and a scale of weekly wages was fixed so as to cover two hours work on Sunday. Applications had been received by three successive Postmasters-General for further pay on Sunday, and had been refused by each. Lord Wolverton thought it his duty to decline to reopen the question.

Australia and United States Cable.—According to the *Standard,* "Sir Alexander Stewart, ex-Premier of New

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South Wales, and Mr. Randolph C. Want, of the Mackay-Bennett Commercial Cable Company, are now on their way from America with a view to arrange for the construction of a new cable between the United States and Australia." This project, which is very old, has been often discussed by men of experience, and invariably pronounced impracticable, or, at all vents, not feasible as a commercial undertaking.

POST OFFICE CLERKS.—A largely-attended meeting of the second-class clerks of the Central Telegraph Office, London, was held on Tuesday evening at the Foresters' Hall, Clerkenwell. A petition was drawn up and numerously signed for presentation to Lord Wolverton (Her Majesty's Postmaster-General), drawing attention to the fact that the petitioners have not received any benefit from the "Fawcett" scheme, formed in 1881, for the bettering of this class of public servants, and praying for an improved establishment.

EARTHQUAKE SHOCK IN ITALY.—A telegram, dated Naples, March 6, says a severe shock of earthquake occurred to-day at Marano-Marchesato, near Cosenza. Several houses fell in. One person was killed and several others injured.—A telegram from Catania announces Mount Etna to be in a state of eruption. Cinders and stones are being continually thrown up; and it is supposed that lava is coming out of the crater, but as it is covered by a dense mist no proper observations can be taken. Slight shocks of earthquake have been felt at the foot of the mountain.

THE LIVERPOOL ELECTRIC SUPPLY COMPANY.—The directors of this company, in presenting their annual report, recommend a dividend at the rate of 6 per cent. on the paid-up capital of the company. The dividends for the two previous years, 1883 and 1884, were at the rate of 5 per cent. per annum. The report states that, in addition to the contract for the whole of the electric lighting of the Liverpool International Exhibition, the company has other important orders on hand, and arrangements are in progress for a large extension of electric lighting from the company's central supply stations.

THE INDIAN TELEGRAPH DEPARTMENT.—With reference to the officers of the Indian Telegraph Department who have not hitherto shared in that advancement which is a feature of the other departments in the State, it may be noted that a recent Government resolution states that correspondence is still proceeding with the Secretary of State regarding the block of promotion in their department, and sanctions a trifling change, which slightly improves the pay of some few officers, but in no way affects the block. The result of this correspondence is anxiously awaited by the officers concerned.

ELECTRIC MUSIC.—M. Semmola, a German investigator, one of the many who have experimented in this direction, has succeeded in producing musical tones from a metal plate by electrifying it intermittently from an induction machine. The plate is supported on an ebonite funnel and is a millimetre in thickness. The terminals of the induction machine are connected to opposite sides of the plates by wires, and the path of the current is interrupted so that sparks strike across. The plate then begins to sound, and it continues to sound even if a Geissler tube or a lead wire is interposed in the break.

THE FRANKLIN INSTITUTE.—At the last meeting of the Franklin Institute the newly-elected president, Colonel Chas. H. Banes, presided, and read a paper on "The Institute in its Relations to the Progress of the Mechanic Arts in Philadelphia." The speaker called attention to the fact that from the time of its organisation the institute has done all in its power to promote the mechanical interests of the city and country. He suggested an "endowed chair of original research," and stated that, while the late Novelties Exhibition had been, from a scientific point of view, a great success, it was not so financially.

HELIOGRAPHICAL.—The silvered balls frequently seen in gardens are advocated by Mr. Hatt, in a note to the French Academy of Sciences, for heliographic purposes, in preference to plane mirrors. Their advantage lies in the greater intensity of the luminous point, which can therefore be seen to greater distances. From experiments made by him during the past summer, he found that with a sphere of a small diameter the image perceived at fifteen kilometres with a lunette had a splendour comparable to that of a star of the second magnitude in a field feebly lighted. Such an image, which can be produced at little expense, would, he thinks, be useful in topographical triangulation.

TELEGRAPHIC ADDRESSES.—The secretary of the Hull Chamber of Commerce has received from the Postmaster-General a reply to a memorial from the Chamber praying for a reduction in the amount charged for the registration of telegraphic addresses. The reduction asked for is from £1. 1s. to 5s., and the answer is to the effect that the actual cost the department incurs in respect of each registration considerably exceeds the sum of 5s., and that any balance that may remain out of the charge of one guinea is far from being sufficient to meet the loss of revenue arising out of the reduction in the number of words in telegrams which is brought about by the use of an abbreviated address.

CONDUITS FOR UNDERGROUND WIRES.—In a recent paper upon this subject Mr. R. W. Pope says:—"While it may be perfectly practicable to insulate arc light wires from the possibility of earth contact, under ground, the difficulty and expense of doing so is materially lessened by the use of an insulating conduit. Upon this question there is an honest difference of opinion between different investigators, some of whom confine their attention to the requirements of the particular branch of service in which they are interested. It being the natural tendency of electricity to seek the earth, it appears wise, if compelled to use subterranean wires, to insulate them as effectually as possible at a reasonable expense."

AN ELECTRIC GIRL!—An American exchange says:—Miss Lulu Hurst, the electric girl, who made such a sensation North and West over a year ago, is now a student in Shorter Female College, at Rome, Ga. Miss Lulu was a poor country girl, who discovered by accident that she could tumble a man out of a chair by merely touching it. She made $100,000 by displaying her power, and is going to spend some of it for an education. Dear me! We have heard of two or three poor country girls who could persuade a man to leave a chair in a remarkably short space of time with the assistance of a poker. Perhaps by "it," however, our exchange means the chair. Anyhow it is very foolish to waste hard-earnt money upon such a thing as education.

THE ELECTRIC LIGHT AND THE LARYNGOSCOPE.—A. H. Vesey, of Upper Bedford-place, W.C., has patented this instrument, in which a small incandescent electric lamp is partially imbedded in some non-conducting material, as cement, contained in a casing which is fixed by a bayonet joint within a tube lined with insulating material, to which is attached a German-silver tube of small diameter, containing the wires conveying the current. On the silver tube slides a piece carrying a rod with a mirror at one end, so that the light may be reflected as desired. At the end of the tube is an ebonite handle, containing a switch and resistance coil, so that the

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strength of current may be regulated. The connecting wires project from the end of the handle, and are connected to a battery.

THE LIVERPOOL INTERNATIONAL EXHIBITION.—This Exhibition, which is to be opened in May, stands in grounds 35 acres in extent, and the buildings comprising the covered portion of the Exhibition will cover about eight acres. The contract for the whole of the electric lighting of the above has been secured by the Liverpool Electric Supply Company. Engines and boilers, capable of indicating more than 700 horse-power, will be supplied by Messrs. Marshall, Sons, and Co., of Gainsborough. 320 arc lamps and 2,000 incandescent lamps will be employed in lighting the building, the necessary dynamos being provided by the Anglo-American Brush Company. The work will be carried out under the direction of Messrs. Holmes and Vaudrey, the managing engineers of the Liverpool Company.

THE MIRROR SOUNDER.—The following suggestion was put before us a considerable time before Von Taund Szyll patented his seleno-differential recorder. Many means had been tried not only for registering the signals of the mirror instrument, but for increasing its accuracy. In the latter direction it seems to be a theoretical possibility that if two independent selenium plates were connected in two independent telephone circuits, so that the effect of the ray of light falling upon each selenium plate would cause each telephone to give out a different sound, there would be a decided gain in point of accuracy. In point of fact the mirror signals could be read by sound ; the only thing is that the light would have to be greatly intensified. The suggestion was due to Mr. Baines, formerly relieving Superintendent of the Eastern and South African Telegraph Company.

THE CITY AND GUILDS TECHNICAL INSTITUTE.—On the 4th inst., Sir F. Bramwell and a number of gentlemen interested in the management of this institution attended the Court of Common Council, and applied for a grant of money in aid of its funds. A letter from Lord Selborne was read, expressing his belief that the institute was doing a vast amount of good, and that the most satisfactory results had been obtained so far. Sir F. Bramwell replied to several pertinent questions put to him by Alderman Cotton. The total income, he said, was £29,550, and the work done was an ample return for the sums expended. The situation of the building at South Kensington was central and convenient, and everything connected with it was in a promising condition. The petition was referred to to the Coal and Corn and Finance Committee for consideration and report.

ELECTRIC LIGHT FOR THEATRES.—Grace to the good sense of managers, the use of the electric light is fast spreading in our London theatres. One of the first to adopt the gentle luminant was that presided over by Mr. R. D'Oyly Carte, the Savoy, which, without exaggeration, is the prettiest and most comfortable place of amusement in the metropolis. The installation acts splendidly, the lamps burn steadily, and are always up to their standard, while the scenic effects—more especially in connection with the gorgeous dresses in the "Mikado"—are considerably heightened by the pure and powerful incandescent. On the occasion of a recent visit we heard very hearty encomiums passed upon the lighting, and, if we add our experience to the experiences of others, it will be in unreserved commendation of a theatre whose ventilation and lighting, apart from the excellence of its performances, are without equal.

TORPEDOES.—The Edison Machine Works of New York are now, it is said, building for the United States Government a number of electrical torpedoes. These are propelled, steered, and exploded from the shore by electricity. For the purpose of steering, two powerful magnets are placed in the after part. When the torpedo is going straight ahead the rudder is held in the centre, but by the operator moving a small lever on the shore the current passes from one magnet to the other, and the rudder is put over in the required direction. A speed at the rate of over eleven miles an hour has been reached on Government tests, but it is expected that this will be exceeded. The charge consists of 400lb. of dynamite. These torpedoes, a contemporary says, have been tested by being anchored in front of a fort and kept under a concentrated fire for hours, until the float has been completely riddled, and they have yet been ready for active service.

A NEW ELECTRIC RAILWAY.—On Tuesday morning an electric railway was opened on Ryde Pier with a successful series of experimental trips, in the presence of the South-West of England Association of Gas Managers, who held their annual meeting at Ryde. The tramway, which runs down the pier, has hitherto been worked by small locomotives, but some time since the directors determined to substitute an electric railway, and entrusted the work to Messrs. Siemens and Co. The prime motor is a gas engine, which is connected by a belt to one of Siemens' dynamos, performing about 1,000 revolvtions per minute. The current is carried by cable to the conductor, which is a rod of channel iron running by the side of the tramway, and supported by brackets fitted on the sleepers and insulated. The ordinary rails, which are of steel, are used as the return current. The current is taken to a motor under under one of the cars by means of a sliding contact. Each train is worked by one of the ordinary passenger carriages, fitted with a motor, and each is capable of carrying about 13 tons. The carriages were driven up and down the railway at the rate of about 12 miles an hour.

OVERHEAD WIRES.—At the last meeting of the Wandsworth District Board of works, the General Purposes Committee having considered the letters from the clerk to the Metropolitan Board of Works, stating that a committee of such Board had been instructed to inquire into, and report upon, the subject of the fall of overhead telegraph and telephone wires during the recent snowstorm, and the expediency of measures being taken by the Legislature or otherwise to secure greater safety to the public; and asking that the surveyors might be instructed to give him information of any damage which may have been caused by the breakage of overhead wires within the area under their jurisdiction ; and from the clerks to the Vestries and District Boards, with reference to the letter from this Board on the subject of overhead telegraph and telephone wires broken during the storm; and the reports of the surveyors as to the damage done to overhead wires in the district during such storm, recommended that a copy of the surveyors' report on the subject be forwarded to the Metropolitan Board of Works. The report was adopted, and copies of the same were ordered to be sent to the Home Secretary and the President of the Local Government Board.

LIGHTNING.—A remarkable effect of lightning has been recently reported by Prof. L. Weber in a German serial. At Ribnitz, in Mecklenburg, during a violent thunderstorm, with rain and hail, about 6 a.m., the lower pane of a window on the first floor was broken by lightning, and a jet of water was thrown upwards through the aperture to the ceiling, where it detached part of the ceiling, and this, falling with the water, broke a small cigar table below. Three bucketfuls of water were afterwards taken from the room. The hole in the window was like that from a bullet, and there were radial

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cracks. The path of the lightning is not very clear, but that it passed through the glass could not be doubted. Some cigars on the table, it may be mentioned, were carbonised. As to the jet of water, Prof. Weber rejects the hypothesis of a sudden generation of vapour forcing up water from the street. Another explanation offered is that the lightning, passing through the window to the street, generated a vortex of air about itself with vacuum in the interior, through which the water was driven as through a tube. A third hypothesis remains, viz., that a conical *trombe* struck the street, was reflected, and passed through the window in the form of a jet of water. In this case the lightning would merely have accompanied or preceded the *trombe*. Prof. Weber seeks further light on such phenomena.—*Nature*.

BOOKS RECEIVED.—"Precautions to be Adopted on Introducing the Electric Light. With Notes on the Prevention of Fire Risks." By Killingworth Hedges. (London: E. and F. N. Spon). There can be said to be only two classes of literature—the instructive and the amusing. The work under review belongs to neither of these classes; it is more properly contemporary with the modern catalogue put forward by any enterprising manufacturer. While purporting to be a treatise of a more or less scientific character, it is in reality but little more than a tolerably ingenious advertisement of Mr. Killingworth Hedges, and the various manufactures of the company he represents. Commencing with a few cut and dried remarks (in which electricity is spoken of as an "invisible subtle fluid") on the rudimentary principles of electric lighting, about 17 pages are devoted to the Hedges switches, the Hedges cutouts, and so forth, from which we pass on to an extensive puff of the Hedges tachometer. The rest of the work is devoted to information of an excessively elementary character, a reprint of the Phœnix Fire Office rules, a further description of the Globe switch and the Globe cut-out, together with a panegyric upon the Globe dynamo, the Globe arc lamp, the Globe lampholder, the Globe carbon, the Globe commutator, and so on; the breaks being filled up with interesting and instructive dissertations upon the Hedges safety plug, and the principles of economy as represented by a judicious purchase of the varied manufactures of Mr. Killingworth Hedges' company. As a catalogue of limited scope we have great pleasure in recommending this publication to our readers; its only drawback viewed from that standpoint is that one has to pay for it.

SUBMARINE CABLES.—Since our recent note upon the subject of the errors in the positions of submarine cables as laid down upon the charts supplied to the electricians of repairing steamers, we have received communications pointing out that in the aggregate these errors are due to the hydrographer. In some instances this may be so, but it is not an answer which can be considered in any sense as an exhaustive one. Carrying our memory back to an actual experience we can remember an instance in which a cable was broken a dozen miles or so from a terminal station. Three charts were in the possession of the electrician of the repairing steamer, and between two of these there was an hydrographical discrepancy of 2min. 30sec. On both of these, after making due allowance for this discrepancy, the cable was wrongly placed. The third chart was hydrographically correct; but there was an error in the cable position of nine miles to the eastward. Had the electrician been forced to depend upon either of these three charts the chances of a rapid repair would have been problematical. Fortunately, however, he chanced upon a fourth chart, which was not only hydrographically correct, but which also showed the true cable line. The curious part of it was that the latter was the work of an outsider, a naval officer who was acquainted with the locality, and who, accompanying the expedition, amused himself by plotting the line upon his own chart by aid of his own observations. We do not mean to accuse the submarine cable engineering staff of incompetency. There never were more competent men than those who had charge of the expedition of which we speak. We do not understand the cause of the errors of which we have spoken, but we are quite convinced that to place the whole of the responsibility upon the shoulders of the Hydrographical Department of the Admiralty is not altogether fair.

THE TELEPHONE IN NOTTINGHAM.—In Nottingham and district, under special license from the Postmaster-General and from the United Telephone Company, the National Telephone Company have the telephone service in their own hands exclusively. The service was established in May, 1881. The exchanges (local) of the company are at Bottle Lane, Basford, Long Eaton, Loughborough, Ilkeston, and a call-office has just been opened at the top of Derby-road, Nottingham. The company have now about 316 miles of wires (chiefly overhead), exclusive of 40 miles erected by them for the use of the Municipal Corporation for its communication with the police and fire brigade stations, the Castle, the Eastcroft, the University College, water and gas offices and works, and the Borough Asylum. The workhouse is also in communication with the training institution at Radford. Bottle Lane and all the subscribers are also in direct communication with Loughborough, Long Eaton, Ilkeston, Bulwell, Basford, Carlton, Kimberley, and Arnold. The latest departure is the establishment of a call office at the shop of Mr. Swinburne, watchmaker, at the top of Derby-road. This office is open to subscribers and the general public, and anyone in that locality may communicate with the residence, office, or other place of business of any of the 337 subscribers connected with Bottle Lane, the public offices departments, police and fire stations, or principal public institutions. The mode of operating is automatic and exceedingly simple. A locked box, with a slit of the size to admit a penny piece stands at one end of the counter. Beyond is an enclosed compartment, in which stands the instrument. By placing three penny pieces (a threepenny bit or two pennies and a halfpenny will not act) the circle is completed and th person put in communication with headquarters. He then mentions the name or number of the subscriber with whom he wishes to communicate, and there is a printed list alphabetically arranged at the service of the visitor. The subscriber may freely converse for three minutes, at the end of which period Bottle Lane intervenes, the circle is broken and cannot be renewed without the deposit in the slit of another magic three pence. And so on indefinitely.

ELECTRIC ARMS AND AMMUNITION.—Many attempts have from time to time been made to employ electricity in various ways in the use of military weapons. We understand that an effort is now being made to perfect and bring into practical usage a new system of firing by electricity adapted for breech-loading small arms of all descriptions as well as weapons of war of the class known as mitrailleuse. The electricity is supplied by means of a small battery in the gun, and is communicated in a simple and effective manner to the igniter in the cartridge shell. While maintaining the exterior form of the present sporting and military arms, and also the trigger, firing pin, chamber and extractor, several parts of the internal mechanism are done away with, including the main and other spring, but the same form of shell is used as in the percussion system, the electric primer being simply substituted in the place of the cap. The relatively small cost of the battery and its connections, as compared with that of the

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complicated lock required in percussion, will, it is believed, result in great economy in the production of new weapons; while the alteration of the existing small arms from percussion to electric fire is easily and inexpensively made. The change in the shell for use in the electric system, by the substitution of the igniter for the percussion cap, is made at small cost, and as the igniter is not destroyed or displaced by repeated firing, it has been found to have, practically, the life of the shell. The continued improvements in the manufacture of sporting and military guns—the changes from the flint lock to the percussion cap, and from that to the central fire, seem to find their fitting climax in the electric system as now perfected in these inventions, which give the power to have within the weapon itself the source of ignition for many thousand rounds, and in the shell the medium for its use, without any change in the external form of the weapon as at present constructed. The generator or battery is simple, solid in construction, and conveniently placed in the butt of the gun. From actual experience, it is alleged, as many as 15,000 ignitions have been obtained from one battery, without any change of the elements, and extreme alternations of temperature seem to have no effect on its efficiency. An average of 5 to 7,000 is therefore considered a safe estimate of the number of shots that can be fired from an electric gun or rifle without change of battery.

THE ELECTRIC LIGHT AT LLOYD'S.—The extensive suite of rooms occupied by Lloyd's in the Royal Exchange has been successfully lighted by electricity, the installation constituting the most recent example of interior electric lighting by means of storage cells, and possessing several special features. The machinery and apparatus are placed in two large vaults in the basement of the Exchange, the current being supplied by two of Elwell-Parker four-pole, shunt-wound dynamos, each giving 200 amperes and 75 volts. These machines are driven at a speed of about 600 revolutions per minute direct from a Davey-Paxman compound semi-fixed engine of 20 horse-power nominal, but which is sometimes worked up to 45 horse-power. This plant supplies the current to about 400 Edison-Swan glow lamps, each of 10 candle-power and 50 volts. Of these lamps there are 192 in the underwriting room, 139 in the reading room, 10 in the telegram room, and fourteen in the committee and writing rooms, the remainder being placed on the staircase, in the vestibule, and in the dynamo room. The installation was completed and the lighting began towards the close of last year, and proved most successful in all respects save one. Soon after the start objection was taken by some to the noise and vibration supposed to have been caused by the engine, which, however, is very quiet and steady in running. It is said, moreover, that complaints have been made when the engine was actually not running, so that the real cause may, after all, have been the traffic in the streets. Be that as it may, all cause of complaint was removed by the introduction of storage cells, which are charged from the dynamo before and, if necessary, after business hours. The battery room adjoins the dynamo room, and in it are compactly arranged two sets of accumulators, each set being composed of 29 batteries, and each battery consisting of three cells joined in parallel, giving 180 amperes. The 29 sets of threes are joined up in series, giving 58 volts. There is therefore a total of 174 cells. They are all Electric Power and Storage Company's cells of the latest type, and the combined accumulators, when fully charged, are capable of supplying the current to the whole of the lamps for about eight hours. Between the dynamos and the batteries is an Elwell-Parker automatic cut-out, by means of which the return of the current to the dynamos is prevented should their rate of working fall below the normal speed. The conductors from the batteries to the lamps are carried in separate troughs, and safety fusible plugs are used throughout. The whole of the current is manipulated from two main distributing switch-boards which were designed by the Electric Power and Storage Company, and which afford facilities for varying the number of cells, both in the charging and discharging circuits.

THE ELECTRIC LIGHT IN COLCHESTER.—A meeting of gentlemen interested in the continuance of the electric light at Colchester took place recently at the Red Lion Hotel. Mr. J. N. Paxman was voted to the chair, and those present included Mr. Crompton and Mr. Christy, of Chelmsford. Mr. E. Thompson Smith, at the request of the Chairman, laid before the meeting the reasons which had induced him to summon it, which he did not from any personal motive, but simply because he, having been concerned in a similar previous meeting, had been asked by Mr. Christy, of Chelmsford, to call the present assembly together at rather short notice. Mr. Smith having further explained the objects of the meeting, the Chairman called on Mr. Christy, of the firm of Christy, Son, and Norris, electrical engineers, of Chelmsford, to make a statement. Mr. Christy then read a carefully-prepared statement with regard to the present plan of working, detailing all its defects, and then gave a proposed scheme for working the lighting without those disadvantages, and with several important improvements. One of the chief faults of the present arrangement was that as much as 82 per cent. of the current was lost from leakage in the mains and cells and elsewhere, owing to the high pressure, and other causes dependent on the present system. He proposed to obviate this to such an extent that the loss would be actually reduced to 10 per cent. on the whole 800 lamps, which he would propose to supply, whereas the loss of 82 per cent. was on the supply to only 300 lamps. He proposed also to work the dynamos in the evening, so that the current would go direct to the lamps, ensuring a good light as well as a constant one. Meters would be employed to check the amount of electricity supplied to consumers, and the current could with perfect ease be applied for motive power as well as lighting purposes. Mr. Christy submitted an estimate of the receipts and expenditure of the undertaking, showing that with 800 lamps a good profit might be expected, and with the increase in the number of consumers which might reasonably be expected, a still better return would result, as the working expenses would not be greatly increased. The existing plant they could buy up as it stood at a very low figure from the present company now in liquidation; and he spoke with great confidence as to the prospect if gentlemen in the town would co-operate to find the capital, leaving it to his firm to carry out the working of the affair according to the scheme he had briefly sketched out. Several of those present asked Mr. Christy various questions, to which he replied. One of these was in regard to the expense of fittings, in answer to which he said that for a shop front £1 per lamp might be considered an average. Mr. Crompton, who as a well-known and prominent electrician had been asked to attend the meeting by Mr. Paxman, stated that he had examimed Mr. Christy's scheme, and felt well satisfied with it. He thought it would work well, and though perhaps Mr. Christy had a little over-estimated the probable profit of the undertaking, he did not think he had done so to any great extent. Altogether he expressed considerable confidence in the project. Ultimately a committee was appointed, consisting of the following gentlemen, who should look into the scheme, and confer upon its practicability:—Mr. Moy, Mr. Paxman, Mr. Sanders, Mr. Wilson Marriage, and Mr. E. T. Smith.

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EFFICIENCY OF THE EDISON-HOPKINSON DYNAMO.

(Continued from page 329.)

We now come to the electrical connections during these experiments. Fig. 2 shows a perspective view of the arrangement, the left-hand dynamo being that used as a motor, the right-hand one being the generator. Fig. 3 shows the connections in diagrammatic form, the thick lines being the connections between the brushes of the dynamos. C shows the generator, M the motor, F_g the field-magnet coils of the generator, F_m the coils of the motor, the current for both coming from the brushes of the generator. R is a resistance used to weaken the field-magnets of M, otherwise the counter electromotive force in M would be equal to that in G, and no current would pass from armature to armature. Upon the variation of the resistance R depends the current passing through both armatures, the higher the resistance the less the current, the lower the resistance the greater the current. From the terminals of the resistance R in the brush connections wires were led to the testing-room and the difference of E.M.F. obtained. This resistance was ·0058 ohm, so that the $\frac{\text{E.M.F.}}{\cdot 0058} = \text{C}$. Fig. 4 shows the connections in the testing room. G is a Thomson galvanometer, C a standard cell (1·453 volt). The circuit from the terminals whose difference of potential was to be measured included two sets of resistances, A D having a resistance of 2,220 ohms, and D B a variable resistance (in fact, the coils of a Post Office pattern Wheatstone bridge were used). When a suitable resistance is unplugged in D B, the galvanometer gives no deflection upon depressing the key, showing the difference of potential between A D = 1·453 volt—that is, the difference of potential between A D is equal to that of the standard cell, the two balancing each other. The difference of potential to be found is now easily obtained from the equation

$$\text{E} = \frac{1 \cdot 453\ (2220 + \text{unplugged resistance})}{2220}$$

For values of E less than 1·453 the standard cell is replaced by a secondary battery cell of known E.M.F., the above arrangement, as will be seen, not then being applicable.

With regard to the dynamometer its constant is 2·705—that is each division of the scale corresponds to a tangential pull of 2·705lb. acting at a radius equal to that of pulley + half thickness of belt.

One revolution of pulley = 3·63ft. advance of belt. Whence, if T represents tension of spring and n the revolutions of pulley per minute

$$\text{H.-P.} = \cdot 000298\, n\, \text{T}.$$

The experiments themselves can now be described :—

1. The two dynamos were run with brushes up and without the fields excited.

Scale on balance = 21·6 divisions
Revs. per min. = 808
Horse power = 5 2

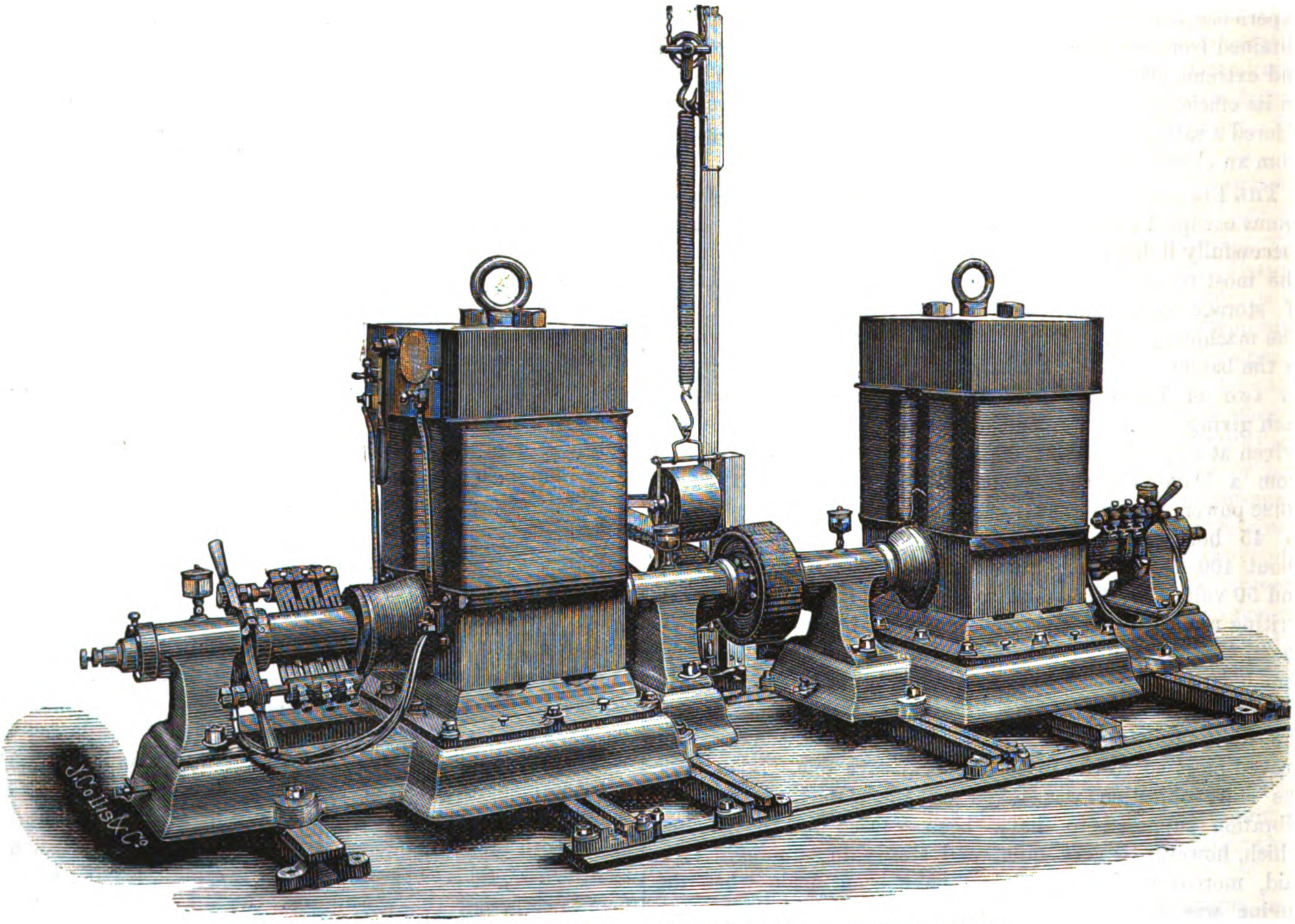

Fig. 2.—Edison-Hopkinson Dynamo, constructed by Messrs. Mather and Platt.

2. The two fields were separately excited, and the dynamos run, still with the brushes off, when

Scale = 30 divisions
Revolutions = 802
Shunt current in field of G = 6·9
" " " " M = 6·7
Horse-power = 7·169

3. The connection were made as in Fig. 3, and the following results of one of a series of similar results were obtained :—

E.M.F. at terminals of generator	=	110 12	volts.
Current	=	358	amperes.
Current through generator magnets	=	6 50	"
Current through motor magnets	=	5·36	"
E.M.F. at terminals of motor	=	107·33	volts.
Speed of machines..............	=	764	revs. per minute.
Power transmitted by belt......	=	6602	watts = 8·850 h.-p.

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Hence—

Total power given o generator	= 42917	watts	= 57 53 h.-p.
Power lost in internal friction of armature core	= 831	„	= 1·11 „
Power lost in generator magnets	= 716	„	= 0 96 „
Power lost in generator armature........................	= 1360	„	= 1·823 „

And therefore—

Commmercial efficiency	= 93 23 per cent.
Loss in core	= 1·94 „
„ „ magnets	= 1·66 „
„ „ armature	= 3·17 „

Similarly for the motor—

Total power given to motor...	= 38886	watts	= 52·13 h.-p.
Power lost in internal friction of core	= 831	„	= 1·11 „
Power lost in motor magnets..	= 472	„	= 0 63 „
„ „ „ „ armature	= 1275	„	= 1·70 „

And therefore—

Commercial efficiency of motor ...	= 93·37 per cent.
Loss in core	= 2·14 „
„ „ magnets	= 1·22 „
„ „ armature	= 3·27 „

In the above experiments Lord Rayleigh's determination of the ohm and of the volt have been taken, and not the B.A. units, as in most previous experiments. The effect of this is to lower the efficiency in comparison with tests made on other dynamos, and at the same time to increase the accuracy of the results.

FIG.3

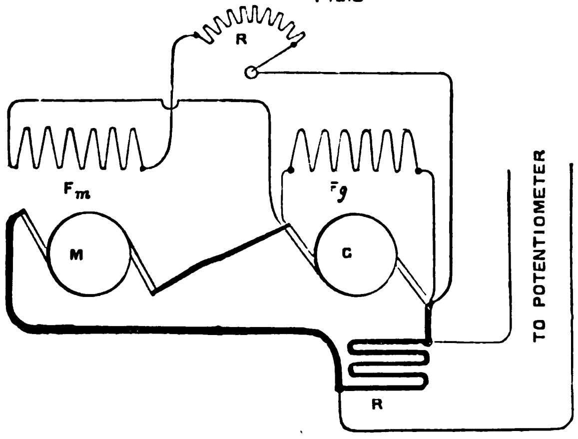
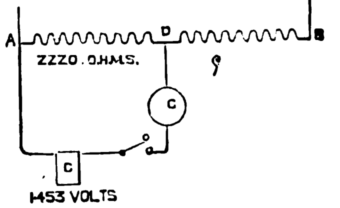


FIG.4



It will be seen that these figures do not take into account one or two minor losses, which tend to diminish the efficiency slightly, such as the friction of the bearings and the bending of the belt round the driving pulley. These losses depend on lubrication and the kind of belt used, so that they are somewhat variable. However, to obtain absolute accuracy the dynamos were run at their proper speed without load and the dynamometer reading noted. The driving engine was then reversed, and the dynamometer again noted. The difference in these readings is twice the friction of the two machines + twice the work done in bending the belt. The loss for one machine was found to be = ·84 horse-power when running at 800 revolutions. Taking also into consideration the variations in friction, if the belt were transmitting full power to drive one dynamo, experiment shows a loss of ·73 per cent. When these losses are deducted from the efficiency above given, the commercial efficiency is seen to be 92·5 for the generator, and 92·6 for the motor. However we look at these figures, we must acknowledge that the dynamo is one of the most efficient machines known to man, and Messrs. Mather and Platt are to be congratulated in producing a dynamo which compares so favourably with any others in the market.

We may mention, in conclusion of this article, that one of the largest Edison-Hopkinson, and probably one of the largest dynamos ever constructed, was shown to the visitors. It is designed to give an output of 50 volts, 1,000 amperes, at a speed of 350 revolutions for electro-deposition purposes.

COMMON MISTAKES IN ELECTRICITY AND MAGNETISM.

BY G. W. VON TUNZELMANN, B.SC.

III.—Voltaic Electricity.

The Electric Current.—If we consider a current of electricity flowing through a portion, A B, of a wire, there are three ways in which the phenomenon may be represented. 1. By a transference in unit time of C units of positive electricity from A to B. 2. By a transference in unit time of C units of negative electricity from B to A. 3. By a transference in unit time of P units of positive electricity from A to B, accompanied by a transference of Q units of negative electricity from B to A. As the same current is described in each case we must clearly have $P + Q = C$.

The third method, with the limitation $P = Q$, is adopted by some Continental electricians in connection with special theories as to the nature of the electric current; but for elementary purposes and for general use the first is preferable, as it is simpler, and does not commit us to any particular theory.

Comparison of Frictional and Voltaic Electricity.—The student will have learned already, in the study of frictional electricity, that electricity can neither be generated nor destroyed, but that the development of a positive electrification must always be accompanied by the development of a negative electrification of equal amount. This may be concisely expressed by saying that the amount of electricity contained in any portion of space can only be increased or diminished by the passage of electricity through the boundary of the portion of space.

Putting it in this way, we see that the motion of electricity is like that of a material fluid, an analogy which is often of great value in explaining electrical phenomena; but in making use of it the teacher should carefully guard against allowing the learner to suppose that in the electric current there really exists anything like an actual material fluid. Every material fluid has inertia, but the experimental evidence is entirely against the ascription of inertia to the electric current. We merely know that in the phenomenon known as an electric current there is motion or transference of some kind, and that whatever it is that is transferred, its transference is like that of a material fluid in that it can neither be generated nor destroyed. We do not know anything about the velocity of transference, whether it be great or small. We do not know whether there is a single transference in one direction, or a simultaneous transference in opposite directions, and, if the former, we have no means of determining which is the actual direction of the motion.

In the development of electricity, either by frictional apparatus or by a voltaic battery, the electromotive force is produced in the same way, viz., by the contact of two dissimilar substances; but in the first case the requisite energy is obtained from mechanical sources, and in the second it is obtained from chemical action.

By the use of frictional apparatus we can obtain a much greater electromotive force than by means of a battery with any practicable number of cells. Thus, Sir William Thomson deduces from experiments that he has made, that a battery of between five and six thousand Daniell cells would be required to produce an electromotive force sufficient to cause a spark to pass between metal plates one twentieth of an inch apart. On the other hand, we can obtain electricity in much larger quantity by means of a battery than by means of frictional apparatus.

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If we bear these facts clearly in mind there will be no difficulty in understanding the reason for the different effects produced by electricity generated respectively by friction and by voltaic action.

In the case of students going beyond the very elementary stage, they will of course learn that by means of induction apparatus a certain quantity of electricity with small electromotive force, produced by a voltaic battery, may be made to develope a much smaller quantity of electricity with a much greater electromotive force.

In his study of frictional electricity the student will have learned that an electrical machine will not continue to develope electricity unless the conductor of the machine be put in electrical connection with the rubber, either directly or by connecting both to the same conductor, such as the earth. In order to charge a condenser, such as a Leyden jar, a break is made at some point of the circuit, and the broken ends or electrodes are connected with the two metallic coatings of the condenser. In place of an electrical machine we may use a voltaic battery, and here again it will be necessary to complete the circuit either by connecting the electrodes directly or by connecting both of them to the same conductor, say the earth, as before. The condenser may then be charged by the battery, just as it was formerly charged by the machine; but as the electromotive force produced by the battery is much smaller than that produced by the machine, the condenser cannot be charged to so high a potential as before.

I have found in my own teaching experience that students are greatly assisted in forming a clear conception of the conditions of flow of an electric current by comparing it with the flow of water through a tube. In this case electromotive force will be represented by difference of pressure, however produced, at different parts of the circuit. In the first place, for the sake of simplicity, let us consider a circuit entirely composed of conductors of electricity, so that for the present we have no condenser in the circuit. Let us fix our attention on a certain portion of the circuit, say a portion of the conducting wire, through which we wish to produce a flow of electricity. Then we know that we must introduce into some part of the circuit some apparatus, such as an electric machine or a voltaic battery, to set the electricity in motion, and to maintain its motion against the resistance of the circuit. In our hydraulic analogue the portion of wire will be represented by a piece of tube filled with water, and the whole circuit by an endless tube filled with water. To produce a circulation in such a tube we must introduce some apparatus of the nature of a pump to set the water in motion, and to maintain its motion against the resistance caused by friction against the tube, and by the viscosity of the water. A pump which can exert a great pressure, but only allows a small current of water to pass through it, will correspond to the electric machine, while a pump which can only exert a small pressure, but which drives a large body of water through it, will correspond to the voltaic battery. If we cut the tube across at some point and connect the ends with a large closed reservoir full of water we get the analogue to introducing the earth as part of the electric circuit. It is clear that the only difference that will be made in a circuit of a given length by replacing a portion of tubing by a large reservoir will be to diminish the friction, and similarly in the case of an electric circuit, as for example in the case of the circuit joining two telegraph stations, if we complete the circuit by connecting the stations to the earth instead of using a double wire the only effect (except a saving in the quantity of wire) will be to very greatly diminish the resistance of the circuit. The effect of introducing a non-conductor into the circuit may be represented by closing the tube at some point by means of a valve, kept shut by a catch, when the circulation will be stopped, unless the pump can exert sufficient pressure to force the valve open by breaking the catch, in which case there will be a flow of water through it corresponding to the disruptive discharge through a non-conductor, produced by a high electromotive force.

Action of a Condenser.—The portion of tube containing the valve may be considered to represent a Leyden jar, or other condenser, for a condenser consists simply of a non-conductor, or dielectric, as it is often called, separating two conductors.

Now, there are two ways of considering the valve and its action. (1) We may suppose that the substance of the valve itself is perfectly rigid, and that the effect of the pump is to compress the fluid on one side of it, and therefore to rarefy it on the other until the pressure becomes great enough to force the valve open. As an enormous force is required to produce a very small compression in water, we shall get a better illustration by supposing the water to be replaced by air or any gas. This compression of fluid on one side, and rarefaction on the other, gives a very good representation of the theory which supposes that positive electricity is accumulated on one coating of the condenser, and negative electricity on the other, and regards the dielectric as simply separating them.

(2) Let us now suppose that the fluid is absolutely incompressible—and here water will do very well to fix our ideas, as it is only compressible to such a small extent—and suppose also that the valve consists of an elastic membrane. Then, as the water is pumped through the tube the membrane will stretch, and if sufficient force be exerted the membrane will break, and the water will be able to pass through.

This will represent the action of a condenser according to the theory which not merely regards electrification as the action of one conductor upon another at a distance from it, but seeks to trace the action in the non-conducting medium surrounding the conductor in the form of some kind of stress produced in this medium. That is the theory of Faraday.

I have assumed the fluid to be incompressible in the second illustration, because it can be proved mathematically that if there is an electric action going on in the dielectric media surrounding conductors—and it must be so unless we admit direct action at a distance—then the flow of electricity will be like that of an incompressible fluid, so that the absolute quantity of electricity in any space can neither be increased nor diminished by any possible means.

If we replace our membrane by one which will undergo a greater extension than the first one under an equal pressure, we get an illustration of the increased charge which can be given to a condenser without increasing the electromotive force, if we replace the original dielectric by one of greater specific inductive capacity.

Development of Heat in the Circuit.—Students are usually able to write down the relation originally determined by Dr. Joule, by experiment, viz.,

$$J\,H = C^2\,R\,t,$$

where R is the resistance of a conductor, C the strength of the current through it, t the time during which the current flows, H the number of units of heat developed in the conductor, and J the dynamical equivalent of heat.

But it very frequently happens that the student's knowledge of the subject is entirely confined to the writing down of this formula from memory, and that when he is called upon to apply his knowledge to special cases he shows that he has utterly failed to grasp the simplest principles.

One of the mistakes most commonly made is to suppose that the heat developed in a circuit containing a battery may be increased by putting in additional resistance. Now assuming, as we may do with sufficient approximation for our present purpose, that the electromotive force of the battery remains constant during the experiment, and remembering Ohm's law that $E = C\,R$, where E is the electromotive force, we may write M, a constant, for C R, and our equation becomes $J\,H = M\,C\,t$, or the heat developed in a given time is simply proportional to the current. Again, suppose we wish to have a large amount of heat developed in a certain portion of the circuit. Then the relation shows us that we must make the resistance of this portion as great as possible compared with that of the rest of the circuit, while making the whole resistance of the circuit as small as possible.

For if R be the resistance of the portion considered, and H the amount of heat developed in it in time t,

And if r be the resistance of the rest of the circuit, and h the amount of heat developed in it in the same time,

Then, since the current must be the same at all parts of the circuit, supposing it to be a single circuit, we shall have

$$J\,H = C^2\,R\,t;\ J\,h = C^2\,r\,t.$$

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$\therefore H : h :: R : r.$

As an example of this, consider the following question from a South Kensington paper:—

The resistances of two wires *a* and *b*, made of the same metal, are as 2 to 3. What are the relative amounts of heat developed in the wire—(1) when they are fastened end to end, and the same current passes through them; and (2) when they are arranged in "multiple arc"—that is, when each connects the ends of the same battery so that the battery current is divided between them.

Answer.—Let R be the resistance of the wire *a*, and H the amount of heat developed in it in time *t*.

Let *r* be the resistance of the wire *b*, and *h* the amount of heat developed in it in time *t*.

First Case.—Since the current is the same throughout the circuit

$$J H = C^2 R t; \; J h = C^2 r t.$$

Therefore $$\frac{H}{h} = \frac{R}{r} = \frac{2}{3}.$$

Second Case.—Let C be the current through *a*, and *c* the current through *b*.

Then we have $$C R = c r;$$

or, $$\frac{C}{c} = \frac{r}{R}.$$

The amounts of heat are now

$$J H = C^2 R t; \; J h = c^2 r t.$$

Therefore $$\frac{H}{h} = \frac{C^2 R}{c^2 r} = \frac{r}{R} = \frac{3}{2}.$$

Magnetisation by the Electric Current.—So many mistakes are made by students in answering questions on magnetisation by the electric current as to show that a large proportion of them have never formed any clear conception of the process. I have frequently seen it stated by students that an iron wire can be magnetised by allowing it to form part of an electric circuit, so that the current may traverse it from end to end. Such a statement as this could not be made by a learner who had ever formed a clear conception of what takes place.

As this is such a very common blunder, I will shortly point out the steps by which the magnetising influence of the current may be explained to the learner, using the language of Weber's theory; the teacher will easily see the modification required if he wishes to make use of the theory of magnetic fluids.

The student should first be shown that an electric current tends to set a freely suspended magnetised needle in its neighbourhood at right angles to its own direction; and he should have given to him at the same time some rule for fixing in his memory the direction in which the needle will turn, relatively to the direction of the current. Ampère's rule is probably as good as any for this purpose, viz.:—

Imagine an observer with his face to the needle to be so placed that the current enters by his feet and leaves by his head, then the north pole will turn to his left.

Now, in order to magnetise a steel or iron bar by means of the current, we place the wire carrying the current near and at right angles to the bar.

Imagine an observer with his face to the bar to be so placed that the current enters by his feet and leaves by his head; then, according to the rule just given, the effect of the current will be to turn each molecule of the bar as far as possible into a direction at right angles to the current, and with its north pole on the observer's left hand, so that the visible effect will be to make the bar a magnet, with its north pole on the left hand of the observer.

I am inclined to think that the gross mistake mentioned at the beginning of this paragraph has been partly caused by a misapprehension of the reason that iron or steel filings adhere to a conductor carrying a current of electricity, for I have even seen it stated by students in explanation of this phenomenon that a copper wire becomes a magnet as long as the current traverses it.

Of course, the real reason is that the filings are first magnetised by the current, and then attracted by it.

I would particularly urge upon teachers that when explaining the effect of an electric current, either upon a freely suspended magnetised needle or in magnetising a bar of steel or iron, the effect should first be shown of a single current passing over or under the magnetised needle or the bar to be magnetised. The learner should then have it shown to him that the effect may be increased by making the current pass in a complete circuit round the needle or bar, and still further by making the current pass through a coil wound many times round it.

If the experiment be shown only with a coil, the learner is very apt to carry away the idea that some magical power is inherent in a coil, a tendency which appears to be very prevalent with beginners, and often results in answers to examination questions which may cause considerable amusement to an examiner, but of which the consequences can scarcely be considered satisfactory either to teacher or pupil.

CORRESPONDENCE.

ELECTRO-CHEMICAL EQUIVALENTS; SELF-INDUCTION IN WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to the query of your correspondent, W. K., I would say that his conjecture respecting the differences between the values of the electro-chemical equivalents is quite correct. Those in my "Dynamo-Electric Machinery" are based on the recent determinations of Lord Rayleigh and of Profs. W. and F. Kohlrausch. The one ampere current deposits, according to the latest information, 4·025 grammes of silver in one hour, or 0·001118 gramme in one second. This makes the electro-chemical equivalent of hydrogen 0·000010352, not 0·0000105 as formerly supposed. At the same time, will you allow me to point out that the figures as given in my "Dynamo-Electric Machinery" agree with those given in the 1885 edition (eighteenth thousand) of my "Elementary Lessons in Electricity." Your correspondent appears to have quoted from an earlier edition. He should see the note at the foot of page 175 respecting the different determinations.

While I am writing may I correct a slip in your report (p. 338) of the remarks I made at the last meeting of the Society of Telegraph-Engineers and Electricians? I certainly did *not* say that pinion wire or stranded wire, if made of copper or brass (or other non-magnetic metal), would possess no advantage over the ordinary round wire; on the contrary, I expressly stated that it would have less self-induction if stranded or of stellate section, but that this would not be due to the same cause that makes a stranded or stellate iron wire have less self-induction than a round iron wire. In the case of iron the advantage arises from the breaking up of the circumferential continuity, thereby diminishing the effective magnetic capacity for peripheral magnetisation by the current. In the case of non-magnetic materials this reason does not exist, and in these cases the sole advantage lies in the fact that in the stranded or stellate conductor the geometrical mean distance between the various parts of the cross-section is greater than in a round wire of equal cross-section; and, in considering the self-induction of a wire, the geometrical mean distance is all-important.—Yours, &c., S. P. THOMPSON.

Finsbury Technical College, March 7th.

CHROMIC ACID IN BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will any of your correspondents kindly help by giving me information on the use of chromic acid in batteries? How is it diluted, and are other acids added? Any information on its powers will greatly oblige.—Yours, &c.,

MIDGE.

(*For continuation of* CORRESPONDENCE *see page* 351.)

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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LORD RAYLEIGH'S ELECTRIC LIGHTING ACT AMENDMENT BILL.

The Bill which has just been introduced in the House of Lords, and which we print elsewhere, for the purpose of amending the Electric Lighting Act of 1882, comes before the public under exceptionally favourable auspices. To begin with, it has the advantage of being in charge of Lord RAYLEIGH, whose reputation as a scientist will be a guarantee that the scientific details of the measure will be competently argued in the Upper Chamber and not gainsaid in the lower. Then, again, there has been ample time to consider the demerits of the original Act, and to formulate with precision the indispensable amendments now demanded. A committee of experts have been at work on the subject for a considerable time; and the Bill before us is no doubt the outcome of their deliberations. It is carefully drawn up, is clear in its provisions, and decisive as to those features of the original Act which it seeks to repeal. At the same time, while securing privileges for electric lighting identical with those conferred on gas lighting undertakings, it accepts all obligations by which the latter are bound, and in fact re-enacts the obligatory sections of the Gasworks Act of 1847 as applicable also to electric lighting works. The public mind has been prepared for this concession not less by its inherent reasonableness than by the conspicuous failure of the original Act, which was at once unreasonable and prohibitive. If the public desire the Electric Light—and we believe they do—they have had ample proof of the terms on which they cannot possibly have it, and are now definitely informed on what conditions alone they may hope to obtain it.

But the prospects of the Bill are promising from another point of view. It virtually takes the initiative. The Act of 1882 died still-born, and Lord RAYLEIGH'S Amendment Bill is to all intents and purposes the first measure on the subject that has been laid before Parliament with any sign of vitality about it. This is a greater practical advantage than may appear at first sight. If Mr. CHAMBERLAIN'S Bill had been backed with an equal weight of authority, or, better still, if it had been clothed in a garb less flaringly "red," it might have had a chance of surviving. But as nobody else offered to legislate on the subject he was entitled to offer his own terms, and to enforce them when he saw that they would be accepted rather than no terms at all. The tables are now turned. It has yet to be seen whether the Board of Trade will resume its singular attitude towards the Electric Light; but in any case it will be compelled to oppose the Amended Bill on some rational principle, if at all, and show cause why the new industry shall not be placed on the same footing as the old. The harsh conditions of the original Act have not checked monopolies, but rather tended to strengthen those already existing; instead of regulating a new industry, it has extinguished it, and the chief provision was one that cannot be defended on any but the most outrageously socialistic principles. We suspect that the Board of Trade will hesitate to avow these principles in this relation. It is one thing to make a hard bargain when a customer is at your mercy, but quite another when you have to defend yourself and lose your customer into the bargain.

It must, however, be said in fairness to the Board of Trade that the Act of 1882 was never very strenuously opposed. Many persons at that time were anxious to get an empowering Bill passed on any terms whatever, and some few, perhaps, were genuinely hopeful that it would do no great harm. Events have undeceived the latter; and as to the former, their object was sufficiently served by the sale of more concessions, which realised vast sums for the vendors, who never intended to work the system on their own responsibility. This fact, combined with the tardy discovery that the public refused fresh capital for schemes which were subject to confiscation at a not very remote date, completely discredited the electric light from a financial or business point of view. Some time must elapse, no doubt, before any marked recovery from these discouraging effects is perceived, even should the present Bill pass through both Houses unimpaired. But on the whole the delay is not without its useful side. Some people, indeed, have contended all along that the failure of the legislative experiment four years ago has been a good thing for electric lighting. It has had time to prove its vitality without parliamentary assistance; it has employed the interval in vastly improving its appliances, and perfecting its organisation, instead of expending enormous capital in undertakings essentially experimental; and, above all, it has shaken off the financial harpies who hung upon its track and made its commercial success an impossibility.

People who express these opinions—and they are men of knowledge and business capacity—are equally emphatic in their favourable predictions for the new illuminant, whenever it is allowed to start fairly under conditions which on the one hand will insure its electrical success, and on the other may promise the legitimate inventor a sure return for his capital. The lessons of the past will suffice—perhaps more than suffice—to avert any fresh outbreak of speculation where the Electric Light is concerned, very much to its advantage as a solid and lasting industry. Handicapped with extravagant prices for concessions that are meaningless and for patents that are unsustainable, no work of the kind can be undertaken with a reasonable hope of competing with gas successfully, much less of making any profit by the attempt. But

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on strictly business lines it ought to succeed in doing both; and if the Act of 1882 is amended in the sense now suggested by Lord RAYLEIGH, we entertain no doubt whatever that these results will follow in due course.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As secondary batteries are now attracting the serious attention which might long since have been well bestowed upon them, consideration is naturally being given to the various devices which, under extended conditions of employment, become essential to their regulation and control.

Notice has lately been especially directed to the necessity of having at hand some simple method for arriving at their state of charge and discharge, and for automatically cutting in or out of circuit at the proper time.

I need hardly say that these are some of the several details essential to their satisfactory working to which I long since gave my attention, and as the question has now been publicly mooted it may be useful to those of your readers who are interested in the subject to be informed that one of my patents, No. 1644, 2nd April, 1883, deals specifically with these points, anticipating the ideas set forth in Mr. Parker's specification, dated 8th August, 1884, of which a full description is given in your last issue.

Certainty of action, together with the utmost simplicity, are desirable in any devices employed for such purposes, and I venture to think that nothing can be more simple, nor, as I have proved by long experiment, more reliable than the means I have described.

With reference to the space in the cell necessary for any such contrivance, an inch at one end is all that is wanted, and this is, or should be, a normal condition, there being advantages in having ample sufficiency of the electrolyte, as also room for its free circulation.

For the proper working of the arrangement described by me, due precaution must of course be taken to ensure equal diffusion of the electrolyte; but this is essential under any and all circumstances, and *must on no account be neglected.* The natural gravitation of the sulphuric acid, as it is discharged from the plates, will quickly cause a difference in density between the top and bottom of the cell, 10, 15, or even 20 degrees, bringing about other evils, such as unequal resistance in the different parts of the cell and consequent uneven work on the plates. Of the two ready methods for avoiding this, the one to be preferred is the employment of a common india rubber valve hand ball, with a tube of glass or vulcanite attached to it for plunging into the cell, with which the liquor can be quickly "blown up" twice or thrice a week—a work, say, of five minutes for every twenty cells. The other method is to overcharge every other day before stopping for two or three minutes, by which the electrolyte is agitated and to some extent mixed.

I need hardly say, however, that much or continuous over charging is to be deprecated as a minute disintegration of the peroxide plate takes place, the fine mud thus formed and deposited tending, in course of time, to bring about contacts, besides, of course, gradually lessening the amount of active material in the plate. The "blowing" process which I have always employed has further the advantage of preventing any accumulation of deposit upon the separating plugs of the plates, a result of much overcharging or of too rapid discharge.

I would observe that by adopting the above described simple method I have experienced no difficulty whatever in regulating my accumulators, and having once given my gardener instructions to charge until the acidometer has risen to a certain mark on the scale (in my case 1220°) I have had no further occasion from month's end to month's end to give any thought or attention to the matter.—Yours, &c.,

Sydenham Hall, March 8th, 1886. JOHN S. SELLON.

I enclose a copy specification, *vide* lines 7 to 30, p. 3, and 7 to 15, p. 5. No. 1644, April 2, 1883:—

My invention has for its object the effecting the cutting out of or putting into the charging circuit of secondary batteries, commonly called electrical accumulators, by means of the motion imparted to an acidometer or other equivalent instrument or appliance, such for instance as a float, or ball, or a vacuum box, which can be made to rise or fall, or be actuated in accordance with the variation in strength, density, or specific gravity (during charging or discharging), of the electrolyte or fluid employed in such batteries.

The motion thus imparted to such acidometer, float, or equivalent instrument (which may be suitably constructed either of metal or of glass or other material with metallic attachments or conductors to cause contacts), actuates mechanical or electrical devices or a combination of the same, or it may act simply by pressure upon a lever shunt valve or equivalent mechanism so that the electrical current is shunted off from or on to the cell or cells thus influenced, and by this means each cell to which such arrangement is attached, or each set or sets of cells in connection therewith which can or may be so controlled thereby, can be cut out of circuit of the charging or main circuit, and can be made to fall in again as required.

For example, one simple arrangement for attaining this end is the employment of a platinum or other suitably-constructed float, situated in or on the solution, and making or breaking contact with the rise and fall of the density of the solution. By the rise and fall of the said float or contrivance, as the density of the solution varies, contacts can be made, and by such contacts, through the medium of a relay or other device, sufficient power may be given to work a switch, or suitable mechanical or electrical contrivance, by which the main charging or the discharging current may be cut in or out as desired * * * *

My invention can be also utilised for the purpose of indicating by the rise and fall of the acidometer, float, or instrument the condition of the batteries at any time—that is to say, either the extent to which they have been charged or the amount of electrical energy remaining in them.

My invention can also be utilised for indicating and registering the amount of current put in or taken out of the cells or batteries, each contact made by the rise and fall of the float or instrument at the time of charging or discharging, actuating by mechanism a ratchet wheel or other suitable device which sets in motion the necessary mechanism.

SECONDARY BATTERY INDICATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You very justly remark in the last edition of *The Electrician* that "the economical advantage of employing secondary batteries is obvious, notwithstanding the first loss of energy," but to say "that until recently the attempts to employ them in distributing stored electrical energy over wide areas have wholly or partially failed for want of an indicator to inform us of the condition of the cells" is scarcely the case.

It would appear from remarks lately published on the subject that the existence of a practically perfect guide as to the condition of cells, and as an indicator and current manipulator, has not been generally known.

Now that the working of secondary batteries is beginning to be better understood, the necessity of a reliable indicator and current manipulator is recognised, not only for isolated installations in order to prolong the life of the plates, but also in distributing stored electrical energy over wide areas.

Having had some experience with an arrangement which depends upon the rise and fall of the specific gravity of the electrolyte, I enclose rough sketches of same, as I feel sure it would interest many to know what has been done in this direction.

Figs. 1 and 2 illustrate an indicator which is very useful for showing condition and quantity of current put into or taken out of cells. A is a platinum or glass bulb or float, which is in the cell. Attached to this is a fine wire of glass, or of platinum, to which is joined a silk thread; this silk thread passes over wheel B, ending with a cup or weight, C, adjusted to the desired weight. This arrangement is similar to the action of a wheel barometer.

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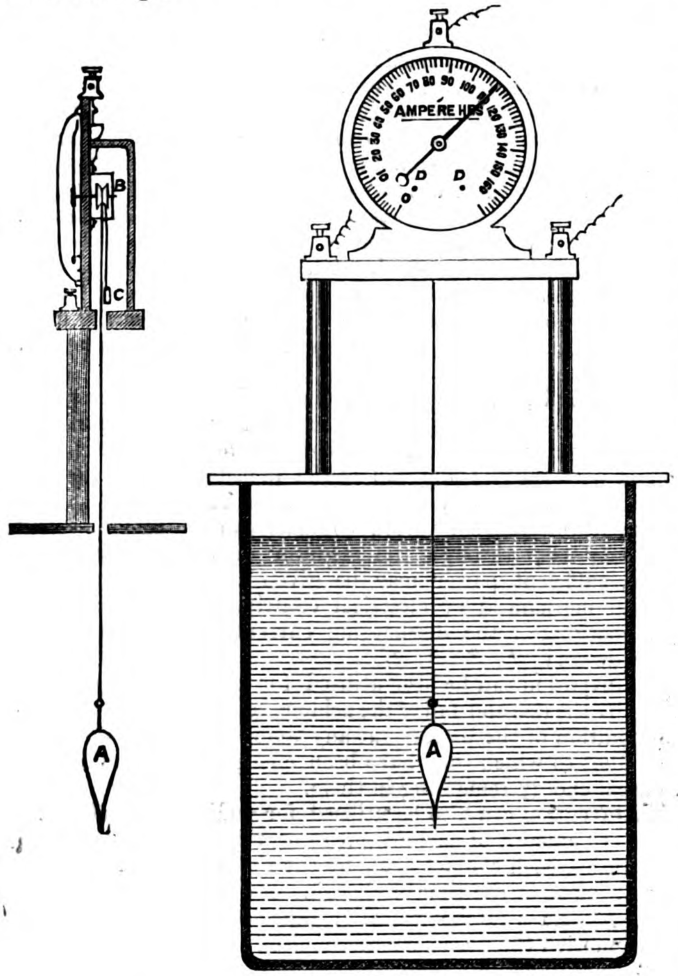
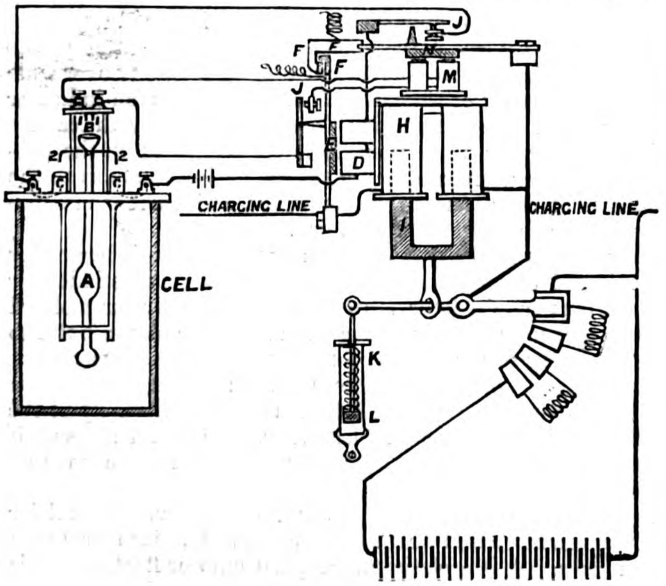
Under ordinary conditions of working, 10 degrees of density may be taken as representing 100 ampere hours, which gives considerable motion to the bulb or float. It is obvious that the wheel B can be made of such a size as to give large or small readings.



Figs. 1 and 2.

Figs. 3 and 4 show an automatic current manipulator or charging switch, wherby any number of sets of cells may be brought in or cut out of the charging circuit, through the



Figs. 3 and 4.

rise and fall of the density of the electrolyte. A is an acidometer hydrometer, the motion up and down of which causes wires 1 and 2 to make contact with the mercury in cups B and C C.

It will be seen by the sketch that on the fall of the acidometer through the discharge of the cell contact is made by wire 2 2 with mercury cups C C; this connects up one or two cells with magnet D. This magnet, by attracting its keeper, E, opens the circuit at F F F; this causes the charging current, if acting, to pass through the wire of solenoid H, which, by attracting its core, I, switches in resistance, short circuits same, and finally connects up the cells with the charging main. Contact springs J J break the connection of magnets D and M, opening the one which has operated, closing the other ready for the next operation. This prevents waste of current which would take place, as the contacts at 1 and B and 2 and C remain closed until an alteration of the specific gravity occurs.

The opposite action takes place on completion of charging contacts being made at wires 1 1 with mercury cup B. This actuates magnet M, which by attracting its keeper, N, causes the end of the keeper E to spring in and lock at F F F, thereby short-circuiting solenoid H, which releases its core, I, spring K in dash pot L, switching in resistance, connecting up, and thereby disconnecting the set of cells from the charging main.

It will be seen that by such an arrangement sets of accumulators can be readily and surely switched in and out of the charging circuit at any desired point of charge or discharge. The above arrangements are the invention of Mr. Sellon, patents for which were taken out by him in April, 1883, or nearly three years since.—Yours, &c.,

March 8, 1886. Henry A. Kent.

RE REGULATION OF SECONDARY GENERATORS IN PARALLEL.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In Prof. Forbes's recent lecture on "Electrical Distribution" he raises the point, that secondary generators placed in parallel will not work practically, on account of the rise of E.M.F. when some of the generators are turned off. This does not appear to be correct; at least, as you will see from the example below, the rise of E.M.F. is very small.

Take a difference of potential of 2,000 volts between the mains.

Say the resistance of the mains is ·582 of an ohm per mile, and that a 20 candle-power lamp takes 60 watts.

Then the current for a generator to supply 100 lamps = 3 amperes (neglecting loss in conversion).

< ¼ mile >		< ¼ mile >		< ¼ mile >	
Source ½ mile R = ·291ω	A	1 mile R = ·582ω	B	1½ mile R = ·873ω	C

The generators (100 light) "A," "B," and "C" are placed ¼, ½, and ¾ of a mile respectively away from the source of current. The current at A = 9 amperes, E.M.F. lost in mains = ·291 × 9 = 2·619 volts, or instead of 2,000 volts you get 1997·3 volts.

In a similar way at "B" you get 1993·9 volts, and at "C" you get 1991·2 volts, instead of 2,000. Now cut out "A" and "B." The E.M.F. at "C" will now be 1997·3 volts, or a rise per cent. of about ·3 volt.

I should be glad to know if any of your readers have from experiment found that this rise is sufficient to materially affect the lamps.—Yours, &c., Reginald J. Jones.

2, Lady Somerset-road, N.W., March 10, 1886.

SHUNTS AND SENSIBILITY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: A little while ago, when examining a cell for slight variations in the current under certain influences, I was led to ask what degree the galvanometer should be adjusted to, by shunting, &c., so as to be most sensitive for indicating any increment or decrement in the principal current. Anybody

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knows that a tangent galvanometer at a low deflection will rise 1° for a smaller addition of current than when at a high deflection, where, for instance, doubling a 70° current gives only 10° more deflection. Thus, although in one sense shunting a galvanometer diminishes its sensibility, there is at the same time a gain in sensibility in so far as the needle takes up its permanent position at a lower degree of the arc. Does it, then, pay on the whole to shunt the galvanometer or not?

My own finding is that there should be a maximum sensibility of indication upon the arc when the needle, either by shunting or for an opposite purpose by using additional turns in the coil, is adjusted to 45°. As, however, I am myself a clumsy mathematician, I should desire a correction or confirmation of this result; and the natural prominence of the question assures me that one or other of your mathematical contributors has probably dealt with it already. If so, I should feel indebted for a reference to the place.—Yours, &c.,

37, Burlington-road, W. E. ALDRED WILLIAMS.
March 6th, 1886.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the letter under the above heading which you published last week, Prof. Silvanus P. Thompson says that I was wrong in stating that 736 watts correspond to one horse-power, and that Lord Rayleigh's recent determination of the ohm and volt has nothing to do with that figure. With regard to the first objection I cry at once peccavi, because I failed to notice that Prof. Thompson bases his calculation on the English horse-power, whereas I had in mind the French horse-power of 75 kilogramme-metres per second. The latter is equivalent to 736 watts, the former to 746 watts. I cannot, however, agree with him in his remark that Lord Rayleigh's determination has nothing to do with this figure. We cannot measure volts or amperes without instruments, and as long as it was doubtful whether the instruments were calibrated to true volts and amperes the knowledge that 736 or 746 watts represent theoretically one horse-power had no practical value. It was only after Lord Rayleigh had actually enabled us to obtain correct calibrations that these figures could be accepted as substantially correct, and could be used in calculations of power and efficiency. Prof. Thompson offers another correction to the review of his book, and this is of a very important character. I refer to his remarks about critical speed. After suggesting that I am not aware of the proper use of the term critical speed, he explains that he uses the term as representing that speed at which the characteristic curve of the machine runs approximately parallel to the line that represents (by the tangent of its slope) the armature resistance. I am at a loss to understand this. How can a curve be approximately parallel to a straight line? Surely your correspondent must have had in mind a particular portion of the characteristic only, and, be it understood, a portion so short that it can be considered as straight. Now, the question arises, what portion? The origin, the middle, or a point far out? I cannot pretend to be able to interpret Prof. Thompson's meaning, and must leave it to him to explain the approximate parallelism between a curve and a straight line, but I am prepared to show that under no possible circumstances can any portion of the characteristic of a separately-excited dynamo (or of a magneto machine) be even approximately parallel to the line which by the tangent of its slope represents the armature resistance. Say we plot the currents from left to right as abscissæ, and the electromotive forces at the brushes of the armature we plot as ordinates. The curve thus obtained is the external characteristic of the separately excited machine, and the internal characteristic we obtain by adding the loss of E.M.F. occasioned by the resistance of the armature. Now, theoretically, the internal characteristic ought to be a straight line drawn at a certain height (which depends, amongst other things, on the speed) above and parallel with the axis of abscissæ. In reality the line is not straight, but has a certain downward tendency which is due to the effect of self-induction in the armature wires. On the other hand, the line representing the resistance of the armature has an upward slope, and I should like to know by what stretch of imagination anyone can consider the two lines as approximately parallel. But this is not all. Prof. Thompson tells us that there is one particular speed at which the approximate parallelism occurs. Are we to understand that by suitably varying the speed we can change the downward slope of either the internal or the external characteristic into an upward slope? By increasing the speed we may raise the curves bodily, but we cannot make them less drooping. In all probability they will become more so, because the effect of self-induction increases with the speed.

Prof. Thompson's definition of critical speed is only applicable to a series machine, and then it must be thus modified:—The critical speed is that speed at which the portion near the origin of the internal characteristic curve approximately coincides with the line that represents (by the tangent of its slope) the total resistance in circuit. A similar definition could be given for shunt machines, but in that case the characteristic is not the curve representing external current and E.M.F.; it is the curve representing shunt current and E.M.F., and therefore virtually that of a series machine.

I am glad Prof. Thompson understands my meaning of the term critical speed. He says: "If the sense in which the writer of your notice uses the term were correct, then no magneto machine or separately excited dynamos could have a critical speed." This is precisely what I do mean. Only self-exciting dynamos have a critical speed, and since motors are excited from an external source, they have no critical speed.

In this matter I wish for nothing better than to be convinced of the contrary, for in that case the problem of self-regulating motors worked in series by a constant current could be solved in a very simple way, and an immense step would be made in the development of an economical system of distributing electricity over large areas. If my views on critical speed be right, special, and probably complicated, regulating apparatus will have to be added to each motor. If Prof. Thompson be right, then all is easy and plain sailing; and I trust he will further address you on the subject, although the etiquette of journalism forces me to remain without name.—Yours, &c.,

THE WRITER OF THE REVIEW.

THE ELECTRIC BOY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read Dr. Stone's letter in your previous number, and have to remark thereon that all the satirical writing which he or others may produce will never deter me from publishing that which I know to be facts regarding electrical phenomena, no matter how slow other men are in adopting my views about electricity. For example, the following paragraph is now going the round of the journals, as if it contained something new:—"Prof. Clausius says that in order to explain the propagation of luminous waves across space it is requisite to admit the existence of a matter susceptible of more subtle division than the ponderable gases; this is the matter to which at present the name ether has been given; Prof. Clausius deems it no other than electricity." It is gratifying to me that Prof. Clausius has now given his adhesion to the foregoing, which was published in my "Theory of Electricity" in the year 1839, copies of which were at that time sent to Faraday, Arrago, and other electricians.

Dr. Stone makes merry about there being two Electric Boys. I therefore state that there is a man in Edinburgh who has made himself obnoxious to others by his utter want of principle, and who, I have been informed, got up an exhibition of an electrical boy after the genuine electrical boy had been exhibited. When I wrote my last letter to you I thought it right to allude to the second and fallacious electrical boy, lest it had been this boy that your correspondent had seen, as I then gave "Hamlet" the benefit of supposing that he was a truthful writer; but his last letter to you has opened my eyes on this point, and I presume those of your readers. In order to be able to test the truth or falsity of the contents of "Hamlet's" note to you (p. 214), I put to him these questions.

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1st. What kind of electrical apparatus was used? 2nd. How was the electricity conveyed to the boy's body?

Instead of answering these questions, "Hamlet" writes:— "My note, p. 214, sufficiently answers Nos. 1 and 2 questions." Now, this is incorrect, for the note contains no answer of any kind whatever to the questions. It is now manifest that "Hamlet" saw neither of the boys, and that his note to you (p. 214) is entirely a fabrication out of his own brain. When one can do such a deed as this under the shelter of an anonymous name his opinion on any subject is unworthy of notice, and can bear no weight with those who love the truth.

Other engagements prevent me at present, but I hope to continue in your columns (if you will allow me) the subject of air in the lungs being the source of electricity in the human body. In the meantime, let me direct your readers' attention to the new discovery in Germany about the coagulation of blood. Formerly, scientists could keep blood from coagulating for only a quarter of an hour; but now it can be kept from coagulating for days, and this independently of the question of temperature, the blood not being required to be kept at the temperature it was at when it came out of the living subject. If the blood be received in vessels lined with oil, or vaseline, or grease, and be covered up with either of these substances it will not coagulate for days, but if any sharp point of foreign matter comes in contact with the blood in these vessels coagulation will begin at once at that point, and extend from it to the whole of the blood. For a century electricians have disputed about the effects produced by the contact of solids, but now we have added phenomena concerning the contact of blood which the Germans have not referred to electrical action; but I believe it is electrical. The oil, vaseline, and grease are non-conductors of electricity, and points are the very best conductors of electricity; hence the difference of their action on the blood. The new-drawn blood contains a certain amount of latent electricity, which, when abstracted, permits the blood to coagulate.—Yours, &c., JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, 8th March, 1886.

[We must now close the correspondence on this subject.—ED. *E.*]

ECONOMY IN ELECTRICAL CONDUCTORS.*

BY PROFS. W. E. AYRTON, F.R.S., AND JOHN PERRY, F.R.S.

I. At the meeting of the British Association in 1881 a most valuable solution of a very important problem was given by Sir William Thomson regarding the proper sectional area to give to a copper conductor used in transmitting electric energy. In the account of his communication given in the Report of the British Association for that year it is stated that "he remarked that (contrary to a very prevalent impression and belief) the gauge to be chosen for the conductor does not depend on the length of it through which the energy is to be transmitted. It depends solely on the strength of the current to be used, supposing the cost of the metal and of a unit of energy to be determined." And he concluded that for twelve hours per day work "the sectional area of the wire in centimetres ought to be about a fiftieth of the strength of the current in webers."

It is, of course, well known that this rule has to be departed from when considerations have to be taken into account other than that of obtaining maximum economy; for example, the necessity in any general system of electric lighting of maintaining the potential difference along the mains constant within certain limits may lead us to adopt a thicker conductor than is given by the rule of one square centimetre per fifty amperes; while, on the other hand, our desire to obtain a large magnetic effect in an electromagnet, or a large electromotive force in a dynamo, induces us to employ a much thinner conductor than the rule indicates. But, at any rate, when the cost of copper and the cost of coal are the leading considerations, it might appear that Thomson's rule ought to be rigidly adhered to, proper allowance being, of course, made in any particular case for the number of hours of working, the cost per ton of copper, the annual rate of interest and depreciation, and the annual cost of an electric horse-power. Indeed, this is the view that we, and possibly other electrical engineers, have taken, and it was not until comparatively recently, when engaged in actual calculations regarding the proper dimensions to give to the conductors in telpher lines, that we recognised that Thomson's solution of the most economical section to give to a conductor was quite inapplicable in a variety of cases connected with electric transmission of power.

II. Let us consider a little more in detail the solution that Thomson gave. He arrived at an expression for the total waste per mile in a conductor arising from the generation of heat and interest on copper which we find convenient to put in the following form:—

$$C^2r + \frac{t^2}{r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where C is the current in amperes, r the resistance of the conductor per mile in ohms, and t a constant which depends on the annual interest on the value of a ton of copper, allowing for depreciation, and the annual cost of an electric horse-power for the number of hours per year that power is required. Our expression (1) is, in fact, the *total* rate of waste per mile *reckoned in watts.**

In order that this may be a minimum for a given value of C

$$C = \frac{t}{r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

If we take £15 as the annual interest (allowing for depreciation) per ton of copper—that is to say, about 12 per cent. on £125, which is a fair estimate for a ton of good conductivity copper, allowing for the value of the necessary amount of insulation; and if we take £15 also as the annual cost of an *electric* horse-power for the number of hours per year that power is required, it is easy to show that

$$t^2 = 297{\cdot}3$$

so that (2) reduces itself to

$$C = \frac{17{\cdot}24}{r}$$

$$= \frac{17}{r} \text{ approximately} \quad . \quad (3)$$

corresponding with about 60 amperes per square centimetre, or 393 amperes per square inch.

Now, supposing that we desire to apply this result to such a case as the following, which will frequently be met with in electric lighting and transmission of power:—What size of copper conductor ought to be employed when a certain amount of power, P watts, has to be furnished at the end of a conductor n miles long, and when the highest potential difference we are allowed to use from considerations of safety, or it may be that is allowed us by the Board of Trade, is V volts?

Let C be the current in amperes, then, since the maximum potential difference must be at the near, or dynamo, end of the line, the potential difference at the farther end will be

$$V - Cnr$$

if r is the resistance per mile of the conductor in ohms, and if the earth be used as the return, or if r is the resistance per mile of the going and return conductor.

$$\therefore P = C(V - Cnr) \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and by Thomson's rule

$$C = \frac{t}{r},$$

hence we have two equations from which to determine C and r. The values of C and r so obtained are

$$C = \frac{P}{V - nt} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

* Paper read at the Meeting of the Society of Telegraph-Engineers and Electricians, March 12th.

* Although it would not avail bankers to reckon that a business which cleared £1,500 a year produced so many watts, yet such a mode of reckoning is very convenient in problems like the one under consideration. With an electric horse-power costing £15 per annum, the business clearing £1,500 annually might be regarded as producing 74,600 watts, and 5 per cent. per annum interest on £120 might be regarded as an income of 298·4 watts.

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and $$r = \frac{t(V - nt)}{P} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

and these are the values of C and r that it might appear ought to be selected in order to obtain maximum economy.

As an example, let

$$P = 10{,}000 \text{ watts},$$
$$V = 200 \text{ volts},$$
$$n = 10 \text{ miles},$$
$$t = 17,$$

then from (5) and (6)

$$C = 333 \text{ amperes},$$

and $$r = 0{\cdot}051 \text{ ohm}.$$

But it is easy to see from (4) that with an initial potential difference of 200 volts, the same power, 10,000 watts, can be delivered at the end of 10 miles of a conductor having the same resistance per mile if, instead of using 333 amperes, we use only 59 amperes, and as the loss of power in heating is proportional to the square of the current, the waste in heating when using the smaller current will be only about the twenty-sixth part of what it would be if we used the current given us by equation (5).

In fact, for each value of r there are two solutions of C which satisfy (4), whereas only one of them can satisfy (2). In this example, then, *twenty-six times as much economy in coal will be obtained by neglecting Thomson's rule as by following it.*

III. Now, what is the explanation of this? The cause cannot, of course, be due to any error in Thomson's reasoning, and it arises from the fact that Thomson's solution gives the minimum value of the expression

$$C^2 r + \frac{t^2}{r}$$

only when C is regarded as a constant, and r as the *sole* variable. But if, as in the present case, both C and r in this expression are variables connected by some equation such as

$$f(C, r) = 0$$

then the equation connecting C and r which makes the total waste a minimum is *not*

$$C = \frac{t}{r}.$$

In fact, when the maximum difference of potentials V is fixed, the current C can only be regarded as a constant when the power *put into the line at the dynamo end*, VC, is given, and when the amount delivered at the other end is, so to say, left to chance. Under these conditions, Sir William Thomson has given us a most useful rule for determining the size to give to the conductor to obtain maximum economy, but his solution can only be used when the value of the current is previously known.

But since, in many practical cases, it is the amount of power that has to be furnished at the distant end of the line that is fixed for us by the contract, C must not be regarded as a constant, and a totally different method must be adopted to obtain the size of conductor to be employed, so that the waste of power in heating the conductor, together with the interest on the value of the copper, may be a minimum. For not merely, as we have shown, does the current of 333 amperes and a resistance of 0·051 ohm per mile, as determined from (5) and (6), lead to twenty-six times as much waste in heating as will be produced by using the equally effective current of 59 amperes with the same conductor, but as we shall show there is a solution of the problem even more economical than this.

IV. If we write $F(C, r)$ for the total waste which is

$$C^2 r + \frac{t^2}{r}$$

and if our supply condition connecting C and r is

$$f(C, r) = 0,$$

then the equation which gives us the minimum of $F(C, r)$ is

$$\frac{dF}{dC} \times \frac{df}{dr} - \frac{dF}{dr} \times \frac{df}{dC} = 0.$$

Hence performing the partial differentiations on our two functions (1) and (4) we have

$$2Cr \times C^2 n - \left(C^2 - \frac{t^2}{r^2}\right)\left(2Cnr - V\right) = 0 \quad . \quad . \quad (7)$$

Eliminating r from (4) and (7) we obtain

$$C^2 - 2C\frac{P}{V} + \frac{P^2}{V^2 + n^2 t^2} = 0 \quad . \quad . \quad . \quad (8)$$

$$\therefore C = \frac{P}{V}\left(1 \pm nt\sqrt{\frac{1}{V^2 + n^2 t^2}}\right),$$

and, as CV, which is the power put in at the dynamo end of the line, must necessarily be greater than P, the power given out at the distant end, it follows that the plus sign is alone admissable. Hence the current that must be used to obtain maximum economy is

$$\frac{P}{V}\left(1 + nt\sqrt{\frac{1}{V^2 + n^2 t^2}}\right) \quad . \quad . \quad . \quad . \quad . \quad (9).$$

Substituting the values employed in the previous example for P, V, n and t, we find that the current that gives maximum economy is

82 amperes,

and from (4)

$$r = \frac{CV - P}{C^2 n} \quad . \quad . \quad . \quad . \quad . \quad . \quad (10),$$

so that the resistance per mile that gives maximum economy is

0·0954 ohm, and not 0·051 ohm.

We may now use the three sets of values of C and r that we have obtained in connection with our example, and find what values they give to the expression

$$C^2 r + \frac{t^2}{r}$$

which represents the total rate of waste reckoned in watts due to the production of heat on the conductor, and to the interest, including depreciation, on the value of the conductor.

A. Using the values of C and r given by (5) and (6), obtained from combining Thomson's condition of maximum economy with the condition of electrical supply, we have for the above expression

$$333^2 \times 0{\cdot}051 + \frac{289}{0{\cdot}051} = 5654 + 5666$$
$$= 11320 \text{ watts}.$$

B. Using the value of r given by (6), and the second value of C given by (4), we have for the above expression

$$59^2 \times 0{\cdot}051 + \frac{289}{0{\cdot}051} = 177 + 5666$$
$$= 5843 \text{ watts}.$$

C. Using the values of C and r given by (9) and (10), the proper equations to be used for obtaining maximum economy, we have for the total waste

$$82^2 \times 0{\cdot}0954 + \frac{289}{0{\cdot}0954} = 641 + 3030$$
$$= 3671 \text{ watts}.$$

Although, then, the current of 82 amperes and the resistance of 0·0954 ohm per mile leads to a greater waste in heating than the current of 59 amperes and the resistance of 0·051 ohm per mile, yet the former are the most economical to employ. In fact it will be found that a conductor having a resistance per mile either greater or less than 0·0954 ohm leads in our example to greater waste than is produced by employing this conductor.

(To be continued.)

DYNAMO TESTS.

(Continued from page 337.)

On looking at the table, it will be seen that the efficiencies for the two tests differ by about one per cent. The agreement of the measurements of the current and potentials as shown in the values of the resistances, calculated from them, is very good. Whether the difference is due to the power measure-

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TABLE II.—(*Edison No. 10 Dynamo.*)

Date	June 1st.				June 1st.			June 4th.		
Time	12·33	2·00	3·15	4·15	6·56	7·45	8·30	11·15	2·35	4·00
Load	Full.	Full.	Full.	Full.	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$
E.M.F. at terminals	125·08	122·67	121·58	122·87	125·41	126·09	122·89	127·81	128·83	125·6
Total E.M.F.	127·35	127·18	126·05	127·27	126·81	128·74	126·85	128·73	130·67	128·33
Current in external circuit	201·48	196·51	194·56	196·48	52·07	107·05	150·60	51·81	103·79	149·92
Current in field	4·021	3·900	3·84	3·93	3·46	3·69	3·74	3·47	3·81	3·81
External resistance*	·6208$_e$	·6243$_e$	·6249$_e$	·6254$_e$	2·408$_d$	1·177$_d$	·8160$_d$	2·467$_d$	1·213$_d$	·8378
Armature resistance	·0208	·0225	·0231	·0220	·0253	·0239	·0256	0167	·0171	·0178
Field, with box	31·10	31·46	31·63	31·27	36·24	34·14	32·83	36·82	33·83	33·01
Field, alone	...	...	...	...	...	...	...	...	...	...
Power applied	37·69	35·98	35·53	36·19	11·556	21·30	28·46	11·459	20·83	28·64
Total electrical energy	35·67	34·20	33·58	34·22	9·449	19·13	26·27	9·548	18·86	26·47
External electrical energy	33·81	32·34	31·74	32·66	8·762	18·11	24·83	8·884	17·94	25·27
Energy in armature	1·178	1·212	1·218	1·182	·105	·393	·820	·0686	·265	·564
Energy in field	·675	·642	·627	·648	·582	·625	·617	·595	·658	·641
Total efficiency	94·61	95·04	94·52	94·56	81·77	89·80	92·30	83·32	90·55	92·44
Commercial efficiency	89·70	89·89	89·34	89·52	75·82	85·02	87·25	77·53	86·12	88·23
Economic coefficient	94·80	94·58	94·51	94·65	92·73	94·68	94·53	93·05	95·10	95·45
% power in armature	3·12	3·36	3·43	3·26	·906	1·85	2·88	·598	1·28	1·97
% power in field	1·80	1·79	1·76	1·78	5·04	2·93	2·16	5·20	3·16	2·24
Number of revolutions	1208·6	1197·6	1193·3	1199·3	1207·6	1207·7	1202·6	1211·7	1211·1	1209·3
Friction of armature	·437	·437	·437	·437	·437	·437	·437	·285	·285	·285
Temperature of air	30·5° C.	30·5° C.	30·5° C.	28·° C.	26·5° C.	27·5° C.	27·0° C.	25·5° C.	28·5° C.	31·0° C.
Temperature of pole-piece	50·5° C.	50·5° C.	51·5° C.	56·5° C.	35·5° C.	44·5° C.	44·0° C.	38·0° C.	45·6° C.	46·7° C.

* The suffix *e* refers to lamps and *d* to "dead" resistance.

TABLE III.—(*Weston No. 7 M. Dynamo.*)

Date	June 8th.				June 12th.				
Time	11·15	12·26	2·27	3·45	12·00	2·00	3·45	4·30	6·00
Load	Full.	Full.	Full.	Full.	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	Full.*	$\frac{1}{2}$
E. M. F. at terminals	156·07	154·84	151·42	151·22	163·66	163·41	163·93	166·48	167·60
Total E. M. F.	165·58	163·99	160·79	160·31	166·07	168·23	172·65	176·30	172·77
Current in external circuit	125·78	124·86	123·13	123·57	33·26	66·27	99·25	133·82	67·68
Current in field	2·378	2·340	2·341	2·332	1·738	1·872	2·163	2·439	1·959
External resistance	1·241$_d$	1·240$_d$	1·230	1·224$_e$	4·921$_d$	2·466$_d$	1·652$_d$	1·244$_d$	2·476$_d$
Armature resistance	·0742	·0720	·0747	·0722	·0689	·0716	·0683	·0720	·0742
Field, with box	65·62	66·18	64·70	64·86	94·16	87·31	75·78	68·25	85·54
Field, alone	...	...	...	...	...	...	...	...	...
Power applied	29·29	29·01	28·07	28·17	8·658	16·223	24·123	33·257	17·08
Total electrical energy	28·47	27·98	27·07	27·08	7·798	15·387	23·25	32·23	16·144
External electrical energy	26·34	25·94	25·02	25·07	7·304	14·53	21·83	29·89	15·22
Energy in armature	1·635	1·562	1·578	1·536	·1131	·446	·943	1·796	·483
Energy in field	·498	·486	·476	·473	·382	·410	·476	·545	·441
Total efficiency	97·21	96·48	96·45	96·12	90·08	94·84	96·38	96·92	94·52
Commercial efficiency	89·92	89·42	89·14	89·00	84·37	89·57	90·49	89·87	89·12
Economic coefficient	92·51	92·68	92·41	92·58	93·65	94·41	93·90	92·73	94·28
% power in armature	5·59	5·39	5·63	5·45	1·31	2·75	3·91	5·40	2·82
% power in field	1·70	1·68	1·69	1·68	4·41	2·53	1·98	1·63	2·58
No. revolutions	1043·5	1039·0	1045·6	1051·7	1041·4	1038·8	1024·1	1058·8	1051·3
Friction of armature	·3115	·3115	·3115	·3115	·1956	·1956	·1956	·1956	·1956
Temperature of air	30·° C.	30·5° C.	30·° C.	30·° C.	29·5° C.	31·° C.	30·5 °C.	29·° C.	28·° C.
Temperature of pole-piece	42·° C.	42·2° C.	42·8° C.	47·8° C.	33·3° C.	35·° C.	36·5 °C.	36·° C.	35·5° C.

* Unofficial.

ments, or to different conditions of lubrication, velocity, &c., is impossible to say.

After the second test the insulation of the armature gave way, making it impossible to repeat the full load measurements, or to test on the partial loads.

EDISON NO. 10 DYNAMO.

Diameter of armature...	$9\frac{11}{16}$in. inside; $10\frac{5}{8}$in. outside.
Weight of machine	4710 pounds.
Number of commutator bars	64
Turns of wire in a coil	1
Length of useful wire in a coil	33in.
Must brushes be adjusted ?	Yes.
Diameter of bearing	$2\frac{3}{8}$in.
Length of bearing	$9\frac{5}{8}$in.
Number turns per minute	1200
Volts for best work	125
Amperes for best work	200

Table II. gives the results of the measurements :—

There is little to say of the full load measurements of this machine. The extreme difference is about one-half per cent ; the greatest difference from the mean one-fourth per cent.

The dynamo was measured twice on the partial loads. The first set was on the same day as the full load tests, the machine being run on open circuit for a couple of hours after the last full load measurement, then tested for quarter load, then run on half load for a while and tested, &c. The second set, made some days later, showed that the machine had not been sufficiently cooled for the first set of measurements. The total efficiencies, calculated from the two sets of measurements, differ for the quarter load about one and one-half per cent. ; for the half load, three-quarter per cent., and for the three-quarter load, one-seventh per cent.

In comparing these total efficiencies, if the difference of armature friction (·152 horse-power) be applied to the first set, we get

	$\frac{1}{4}$ load.	$\frac{1}{2}$ load.	$\frac{3}{4}$ load.
First set	83·10	90·51	92·83
Second set	83·32	90·55	92·44

But as the measurement of friction was made after the three-quarter load in each case, the values for this load should agree better than for the others. Part of the difference of ·39 per cent. is undoubtedly due to the fact that in the last set of measurements the unsteadiness of the potential galvanometer

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while measuring the armature resistance, due to changes in the contact resistance of the brushes, was so great that the brushes were held against the commutator, thus giving too small a value of r_a, and therefore of $E/_t$. On the whole, the agreement of the two sets is very satisfactory.

WESTON NO. 7 M. DYNAMO.

Diameter of armature	9¾in.
Weight of machine	3,300
Number of commutator bars	64
Total number of turns in coils	128
Turns per commutator segment	2
Average length of a turn	6ft. 8in.
Must brushes be adjusted?	slightly.
Diameter of bearing, pulley end	2in.
Diameter of bearing, commutator end	1½in.
Length of bearing, pulley end	7½in.
Length of bearing, commutator end	6½in.
Number of turns per minute	1,050
Volts for best work	160
Amperes for best work	125

Table III. gives the results of the measurements:—

As stated under "potential measurements," there was a sharp change in the value of the constant of the potential galvanometer between the second and third tests. The following are the calibrations made:—

Time.	Value of K_{50}.	Method.
A.M.	at 25 degrees.	
10·00	1·305	Voltameter with standard resistance.
11·35	1·307	Current galvanometer with German-silver strips.
P.M.		
12·50	1·308	Current galvanometer with German-silver strips.
2·50	1·287	Current galvanometer with German-silver strips.
3·05	1·286	Voltameter with standard resistance.
4·15	1·286	Voltameter with standard resistance.

For the first two tests, the value 1·306 was used; for the last two, 1·286.

(To be Continued.)

LIGHTHOUSE ILLUMINANTS.

On Wednesday evening, at a meeting of the Society of Arts, held at their house in John-street, Adelphi, a paper on "The Experiments with Lighthouse Illuminants at the South Foreland," was read by Mr. E. Price Edwards, who pointed out that the only illuminating agents that had successfully born the tests of experiments and experience were oil, gas, and electricity. They were the only three sources of light upon which complete dependence might be placed. Electricity had been employed in this country with success since 1862, and its limited use was due rather to a dislike on the part of mariners to its extremely dazzling light when they were close to it than from any practical difficulties in its installation. As to the machines used for its generation, some trials were made in 1876, and the verdict then was in favour of Siemens's dynamo machines, and accordingly they were adopted at the Lizard in 1877. In consequence, however, of some serious irregularities in these machines, one of Baron de Meritens's new generators was tried at the Lizard, where it had worked satisfactorily for several years. During the trials at South Foreland the machines were worked either singly or coupled up with two machines in series, and occasionally with three machines in quantity. The lights shone were produced by either one machine, with an average current of 125 amperes, and E.M.F. of 51 volts; two machines in quantity for one arc light, with an average current of 176 amperes, and E.M.F. of 60 volts; two machines in series for one arc light, with an average current of 182 amperes, and E.M.F. of 60 volts; three machines in quantity for one arc light, with an average current of 180 amperes, and E.M.F. of 60 volts. It would be seen that the most effective results were obtained with two machines coupled in series feeding one arc light. As to the arrangements for the electric light, the regulation and control of the arc light produced between two carbon terminals were mainly dependent upon the action of the lamp or regulator, the delicate and ingenious mechanism of which kept the carbon points as nearly as possible the same distance apart. The carbons which gave the best results in the trials were the Berlin core carbons, supplied by Messrs. Siemens, 40 mm. in diameter, and with a core of graphite running through the centre. With alternating currents the electric arc could generally be maintained with a fair amount of steadiness with carbons that were tolerably homogeneous in their composition. The Berlin carbons, with their graphite core, were found to burn with exceptional steadiness, possibly because the centre core afforded the current an easier and consequently more regular course. As to the results of the experiments, it was found at a comparatively early stage of the trials that no practical advantage was gained by superposing electric lights, but that a sufficiently effective result was obtained from one arc fed by two electric machines. This form of light was accepted by the committee as that best suited for the exposition of the electric system, and that upon which it should be judged in respect of its merits as a lighthouse illuminant. In stating the results of the trials, it would be sufficient to regard each light as shown in its highest power—viz., electric, one light, two machines; gas, four lights, 108 jets; oil, three lights, six wicks. In fine weather it was evident that all the lights were too good, and that no one was really better than another; in fact the lower powers of any one of the illuminants would be sufficiently serviceable for the requirements of the mariner, either as a a fixed or a revolving light. The general result of all the observations made in respect of haze showed incontestably that the single electric light, as shown from the A tower, greatly excelled the most powerful superposed gas or oil light in penetrating power, either as a fixed or revolving light. Of 284 eye observations recorded as made in weather not clear, but without actual fog, the mean percentage of superiority of the electric light over gas was about 36, and over oil 41. The general verdict of superiority of the electric light in such conditions of weather was plain and unmistakable. It was always better than anything else. In actual fog, the electric light again held its own, and it was proved beyond question that the single electric light pierced a greater depth of fog than the highest powers of either gas or oil; while the quadriform gas and triform oil lights were practically equal in fog. The recorded distance to which lights were carried, or where they were picked up in the fog, ranged mostly between 700ft. and 2,000ft. from the lights themselves; and the superiority of the electric light was determined by its penetrating 200ft. or 300ft. further than the gas or oil lights. But for the purposes of navigation a difference in the visibility of the lights of 200ft. or 300ft. was of no value whatever. The whole result might be approximately stated as follows:—For expenditure of raw material only, without reference to plant, labour, &c., a six-wick mineral oil lamp burning for six hours would consume four gallons of oil at 6d. = 2s., or, say, 3s., including wicks, cylinders, &c. A 108 jet burner alight for the same period would consume 1,800 cubic feet of gas, at a cost of not less than 10s. for coal alone. Taking all these considerations into account, it would not be surprising to hear that the final conclusion of the committee was:—"That for ordinary necessities of lighthouse illumination mineral oil is the most suitable and economical illuminant; and that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages."

At the conclusion of the paper there was a short discussion, in which the chairman, Prof. Adams, Mr. Vernon Harcourt, F.R.S., and others took part.

ELECTRIC LIGHTING ACT (1882) AMENDMENT BILL.

(Introduced in the House of Lords by Lord Rayleigh.)

Whereas it is expedient that undertakings for electric lighting should be put in the same position with gas undertakings, both as regards the privileges and the obligations of undertakers, and for this purpose it is necessary to amend and extend the Electric Lighting Act, 1882. Be it enacted, &c.:—

Sections 1 and 2 relate to definitions.

3. Section 12 of the Electric Lighting Act, 1882, shall be read and construed as if the portion of Sub-section 2, commencing with the words "and with respect to waste," and ending with the words "approved of by the undertakers," had been omitted, and instead be it enacted as follows:

4. Every person who shall lay or cause to be laid any conductor to communicate with any electric line belonging to the undertakers without their consent, or shall fraudulently injure any meter used for ascertaining the quantity of electricity consumed or supplied, or who, in case the electricity supplied by the undertakers is not ascertained by meter, shall use any lamp other than such as has been provided or approved by the undertakers, or any lamp calculated to expend more electricity than he has contracted to pay for, or shall keep the lights burning for a longer time than he has contracted to pay for, or shall otherwise improperly use or expend such electricity, or shall supply any other person with any part of the electricity supplied to him by the undertakers, shall forfeit to the undertakers the sum of *five pounds* for every such offence, and also the sum of *forty shillings* for every day such conductor shall so remain, or such works or lamp shall be so used, or such excess be so committed or continued, or such supply furnished, and the undertakers may cut off the supply of electricity from the house and premises of the person so offending, notwithstanding any contract which may have previously been entered into: Provided that nothing herein contained shall, where the damage sustained by the undertakers is in excess of the sums to be forfeited as aforesaid, prevent the undertakers from recovering such excess from the consumer by action.

Sections 5 and 6 relate to penalties for wilful damage, &c.

7. Section eighteen of the Electric Lighting Act, 1882, is hereby repealed, and instead thereof be it enacted that where electricity is supplied by meter no local authority, company, or person shall be at liberty to use any form of lamp or burner, or to use the electricity supplied to them for any purposes, or to deal with it in any manner so as to unduly or improperly interfere with the supply of electricity supplied to any other local authority, company, or person by the undertakers, and if any dispute or difference arises between the undertakers and any local authority, company, or person entitled to be supplied with electricity under this Act or any license order or special Act as to the matters aforesaid, such dispute or difference shall be determined by arbitration.

8. Section twenty-seven of the Electric Lighting Act, 1882, is hereby repealed.

9. Where any undertakers carrying on the business of supplying electricity for their own benefit are authorised by provisional order or special Act to supply electricity within any area, the amount of profit to be

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received by the undertakers in respect of their undertaking within such area shall be regulated as follows:

(1.) The profits of such undertaking to be divided amongst the undertakers in any year shall not, save as hereinafter provided, exceed the prescribed rate, or where no rate is prescribed exceed the rate of *ten pounds* per centum per annum (which prescribed rate or rate of *ten pounds* per centum, as the case may be, is hereinafter referred to as the standard rate of dividend) on the paid-up capital which shall be authorised by the order or special Act, and shall from time to time be appropriated to and expended on or in connection with such undertaking, unless a larger dividend be at any time necessary to make up the deficiency of any previous dividend which shall have fallen short of the said yearly rate: Provided that the undertakers may increase and shall diminish such standard dividend by relation to a decrease or increase in the standard price (to be fixed by the order or special Act) per electrical unit, in accordance with the principle of the sliding scale now applied to gas undertakings, except that having regard to the small price charged per electrical unit as compared with the price charged per one thousand cubic feet for gas, the standard dividend shall be reduced or increased by *five shillings* in the one hundred pounds per annum in respect of every *one farthing* (instead of as in the case of gas every one penny) charged in excess or in diminution in any year of such standard price per electrical unit:

(2) If the clear profits of the undertaking in any year amount to a larger sum than is sufficient, after making up the deficiency in the dividends of any previous year as aforesaid, to make a dividend at the maximum rate hereinbefore authorised, the excess beyond the sum necessary for such purpose shall from time to time be invested in Government or other securities, and the dividends or interest arising from such securities shall also be invested in the same or like securities in order that the same may accumulate at compound interest until the fund so formed amounts to the prescribed sum, or if no sum be prescribed a sum equal to *one-tenth* of the nominal capital of the undertakers appropriated to the undertaking, which sum shall form a reserved fund, to answer any deficiency which may at any time happen in the amount of divisible profits, or to meet any extraordinary claim or demand which may at any time arise against the undertakers, and if such fund be at any time reduced it may thereafter be again restored to the said sum, and so from time to time as often as such reduction shall happen:

(3.) Provided always that no sum of money shall be taken from the said fund for the purpose of meeting any extraordinary claim unless it be first certified in England or Ireland by two justices, and in Scotland by the sheriff, that the sum so proposed to be taken is required for the purpose of meeting an extraordinary claim within the meaning of this Act or the order or special Act:

(4.) When any such fund shall by accumulation or otherwise amount to the prescribed sum or *one tenth* of such nominal capital as aforesaid, as the case may be, the interest and dividends thereon shall no longer be invested, but shall be applied to any of the general purposes of the undertaking to which the profits thereof are applicable:

(5.) If in any year the profits of the undertaking divisible amongst the undertakers shall not amount to such maximum rate as aforesaid, such a sum may be taken from the reserved fund as with the actual divisible profits of each year will enable the undertakers to make a dividend of the amount aforesaid, and so from time to time as often as the occasion shall require.

10. Where under any provisional order or special Act authorising a company to supply electricity within any area, a certain sum has been prescribed as the original capital appropriated to the undertaking within such area, then when under any further provisional order or special Act any additional capital is to be created and issued in respect of such undertaking, the undertakers shall, notwithstanding anything contained in the special Act or Memorandum or Articles of Association or other document under which they are incorporated, offer the same for sale by public auction or by tender within the metropolis or other prescribed place, in such manner, at such times, and subject to such conditions of sale as the undertakers shall from time to time determine: Provided that—

Here follow provisions similar to those in force relating to Gas Companies' Shares, concluding as follows:—

Where under such order or special Act a local authority or person other than a company is authorised to supply electricity within any area, any new or additional capital issued in respect of the undertaking within such area shall be offered by public auction according to rules prescribed, or if no rules are prescribed then as nearly as the case will admit in the manner hereinbefore provided in the case where the undertakers are a company.

11. The undertakers shall upon being required so to do by the owner or occupier of any premises situate *within twenty-five yards* from any main of the undertakers, or such other distance as may be prescribed, give and continue to give for the purpose of lighting a supply of electricity for such premises under such pressure in the main as may be prescribed, and they shall furnish and lay any electric service line that may be necessary for such purpose, subject to the conditions following (that is to say):—

The cost of so much of any electric service line for the supply of electricity to any owner or occupier as may be laid upon the property of such owner or in the possession of such occupier, and of so much of any electric service line as may be laid over a greater distance than *thirty feet* from any main of the undertakers, although not on such property, shall be defrayed by such owner or occupier.

Every owner or occupier of premises requiring a supply of electricity as aforesaid shall—

Serve a notice upon the undertakers at their offices specifying the premises in respect of which such supply is required and the day (not being an earlier day than a reasonable time after the date of the service of such notice) upon which such supply is required to commence;

Enter into a written contract with the undertakers (if required by them so to do) to continue to receive and pay for a supply of electricity as aforesaid for a period of at least *two years* of such amount that the rent payable for the same shall not be less than *twenty pounds* per cent. per annum on the outlay incurred by the undertakers in providing any electric service line to be provided by them for the purpose of such supply; and

Give to the undertakers (if required by them so to do) security for the payment to them of all moneys which may become due to them by such owner or occupier in respect of any electric service line to be furnished by the undertakers and in respect of electricity to be supplied by them:

Provided always that the undertakers may, after they have given a supply of electricity to any premises, by notice in writing require the owner or occupier of such premises within *seven days* after the date of the service of such notice, to give to them security for the payment of all moneys which may from time to time become due to them in respect of such supply in case such owner or occupier has not already given such security, or in case any security given has become invalid or is insufficient, and in case any such owner or occupier fails to comply with the terms of such notice, the undertakers may if they please discontinue the supply of electricity for such premises so long as such failure continues.

12. The undertakers shall supply electricity for street lighting by any lamps of an electrical character to be approved by the undertakers, within the distance of *fifty yards* from any of the mains of the undertakers, in such quantities as the local authority may from time to time require to be supplied, and the price to be charged by the undertakers, and to be paid to them for all electricity so supplied shall be settled by agreement between the local authorities and the undertakers, and in the case of difference by arbitration, regard being had to the circumstances of the case and the prices charged to private consumers in the district. Any difference which may arise between the undertakers and any local authority in relation to the supply or consumption of electricity to or by such local authority shall be settled by arbitration.

13. All undertakers authorised by provisional order or special Act to supply electricity within any area shall, unless prevented by necessary repairs or unavoidable accident, at all times keep all their mains supplied with electricity up to the prescribed pressure.

14. Whenever the undertakers neglect or refuse to give for the purpose of lighting a supply of electricity to any owner or occupier of premises within the area of authorised supply entitled to the same up to such pressure as is prescribed, they shall be liable to a penalty not exceeding *forty shillings* for each day during which such default continues:

Whenever the undertakers neglect or refuse to supply electricity as by this Act required for street lighting in accordance with the provisions of this Act, they shall be liable to a penalty not exceeding *forty shillings* for such default:

If it shall be proved to the satisfaction of any two justices, not being shareholders in the undertaking, after hearing parties that on any day the electricity supplied by the undertakers was below the prescribed pressure, the undertakers shall in every such case forfeit and pay to the local authority, or other persons, making application for testing the electricity such sum not exceeding *twenty pounds* as the justices shall determine:

Provided that no forfeiture shall be incurred in any case with respect to which it is proved that the insufficiency of pressure was occasioned by unavoidable cause or accident.

[Here follow further provisions as to how the penalties are to be borne and enforced.]

15. Where any undertakers are authorised by license, order, or special Act to supply electricity within any area, any local authority (being an urban authority within the meaning of the Public Health Act, 1875) within whose jurisdiction such area or any part thereof is situated, may (with the sanction of the Board of Trade), by agreement with such undertakers, purchase, and such undertakers may sell to them their undertaking or so much thereof as is within their jurisdiction upon any terms, and on the terms of such purchase being carried out the powers of such undertakers so far as relates to such area or the part thereof within such jurisdiction shall be transferred to and vest in such local authority.

16. All offences and penalties under this Act, and all money forfeited and all money and costs by this Act directed to be recovered as penalties, may be prosecuted and recovered before a court of summary jurisdiction.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF COMMONS, March 5.

The adjourned debate on the Post Office Submarine Telegraph Contract (St. Vincent to the West Coast of Africa) was resumed. On the question being put "That the contract dated the 19th day of January, 1886, for the construction of a submarine telegraph line from the Island of St. Vincent to the West Coast of Africa be approved,"

Mr. Henniker Heaton said he rose to oppose the motion, and to move as an amendment "that the whole question should be referred to a Select Committee of the House." The cable which under this contract the Government agreed to subsidise for the purpose of its construction was already constructed when the contract was entered into on the 19th of January, 1886. The cable was constructed by the India Rubber and Gutter Percha Company, and it seemed to him that the Treasury minute on this subject was entirely misleading. The person at the bottom of this matter was a gentleman who was greatly mistrusted by those who had any knowledge of these matters—he meant

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Mr. John Pender; and in asking for a Select Committee to examine into all matters connected with this contract he thought he was making a very reasonable request of the Government. The contract which the House was now asked to sanction bound the British Government to pay £380,000 for the construction of a telegraph cable from St. Vincent to the West Coast of Africa. The company had already a line of cable on the East Coast of Africa, for which the Government paid a subsidy of £25,000 a year. By now obtaining the contract for the West Coast of Africa the Company would obtain a practical monopoly, and he was sure that the House would not submit to a contract of this nature being entered into without the most searching inquiry. He believed that the time had come for the Government of this country to own these cables that connected England with our great colonies, and the effect of this contract was to throw the monopoly of the cable to Australia into the hands of John Pender and Company. While these large subsidies were being paid to one company there was no hope of inducing the Government to construct cables themselves. He had already given notice of motion to the effect that the Government should construct an alternative line of cable round the West Coast of Africa to the Cape of Good Hope, but if this contract were approved his proposal could not be adopted. As announced in *The Times* of the 13th of October, the Gutta Percha Company agreed to construct the cable from St. Vincent to the West Coast of Africa and thence to the coast of Australia without subsidy. Without warning John Pender and Company came in, and after the cable had been laid down, purchased the rights of the company, and now endeavoured to obtain a large sum of money from the Government as a subsidy for the construction of the cable, although, as a matter of fact, it was already laid down and almost in operation. If an inquiry were granted he would pledge himself to produce evidence to show that the contract was not an honest one. He begged to move that the matter be referred to a Select Committee of the House.

Sir H. HOLLAND defended the late Government, and said, although it was true that the India Rubber Company had agreed to lay down a line from St. Vincent, the line was a quasi-foreign one with which they could make no terms. The hon. member said that the Company had now established a monopoly and could charge what rate they pleased, but if he looked at the contract he would see that the rates were laid down and fixed by it. Both the companies tendered, and they both required a subsidy. He denied that they had laid the line in July last. The late Secretary of State for War and the late Colonial Secretary and he himself went again and again over the question of the amount of the tenders and the amount of the subsidy; and the result was that it was reduced to £19,000, which was lower than the subsidy required by the India Rubber Company. The Treasury had no option but to take the best terms they could obtain from the Company that would lay down the line to the West Coast of Africa.

Mr. H. FOWLER said that the charge of the hon. member for Canterbury was that they were entering into a contract that was not an honest one. Now, that question had been before three different Governments for a succession of years, and it had been most carefully considered. The matter involved two points—namely, a question of policy and a question of internal administration. On the first question he frankly conceded that the House had both the right and the duty to express its own opinion. That question was whether it was for the political and the commercial interests of this country that a telegraph cable should be laid to the West Coast of Africa. If the House referred to the Treasury minute of February they would find that the Treasury were of opinion that that scheme would be of advantage both to the West African colonies and to this country commercially and politically. The question was raised in the first instance under the former Administration of the present Prime Minister, and it was considered by the Cabinet of that day that it was for the interests of this country that there should be telegraphic communication with our settlements in West Africa. Anybody who was aware of the grave public inconvenience that had been suffered from the want of that means of communication would be of opinion that the Cabinet decided rightly. That decision was confirmed by the Cabinet of Lord Salisbury, and again by the present Government. The Treasury invited tenders, and they received three, one of £23,000, another of £29,000, and another as high as £102,000. They decided to accept the one for £23,000. There was a difficulty in the way, arising in connection with the Island of St. Vincent not being British territory; but that difficulty having been got over, the company was in a position to complete the contract. Negotiations were opened, and he must express his admiration of the manner in which the late Chancellor of the Exchequer was enabled to reduce the subsidy to £19,000, of which the colonies themselves would contribute £5,000. The English Government were only to pay half rates; they were to have priority for their messages and to have the right to nominate a director to protect their interests; while in time of war they were to take possession of the telegraph. The House was asked to withhold its confidence from the Treasury, and to refer the contract to a Select Committee. That was not the mode in which the public business either had been or ought to be conducted. The hon. member for Canterbury, before he concluded, had rather unveiled what was behind. The hon. member said he was very anxious that there should be another cable laid to Australia, and that the Government should own all those submarine cables. They knew what that meant. They knew that the Government paid between £10,000,000 and £11,000,000 sterling for the purchase of the telegraphs, which, he supposed, were not worth above half that sum. And now probably some people would like the Government to buy up the submarine telegraphs also. He, however, hoped that the Government would do nothing of the kind.

Mr. LABOUCHERE criticised the contract, and strongly supported Mr. Heaton's amendment.

Mr. MUNDELLA said the negotiations for this contract had been commenced by the last Liberal Government and concluded by the late Government on the most economical terms, and he could not understand the hon. member for Northampton opposing it. The contract was put up for tender, and one tender was for £23,000 a year, another for £29,000 a year, and a third for over £100,000 a year. The late Chancellor of the Exchequer reduced the first tender to £19,000, and at that sum the contract was concluded, special care being taken in regard to the terms and conditions, and it being arranged that £5,000 a year should be paid by the colony towards the £19,000. Under such circumstances he hoped the House would not be misled by the hon. member for Northampton.

Sir M. HICKS-BEACH said he took immense trouble with this contract, and he believed that in the tender as cut down to £19,000 the country had an exceedingly good bargain. This cable would save many thousands a year by securing telegraphic communication between this country and our colonies in Africa, and thus tending to guard us from native wars. The commercial advantages would also be very great.

Mr. MOLLOY asked whether it was not a fact that the India Rubber Company, a solvent company, were prepared to lay the cable at their own expense, and that some person stepped in, purchased the contract, and then came to the House for a large subsidy. Unless a more satisfactory explanation than had been as yet given was furnished he should oppose the vote.

Mr. MUNDELLA begged to state, by permission of the House, what had been already stated half a dozen times, that the India Rubber, Company asked for £29,000 a year, that they only laid a small section of the cable, and when they got the contract for the whole distance they handed it over to another company who did it for £19,000.

After some further remarks by Mr. ILLINGWORTH and Sir E. STANLEY, Mr. H. FOWLER said, in answer to Mr. BRUNNER, that the India Rubber Company asked between £20,000 and £30,000. The company proceeded to lay a small portion of the cable—about one-sixth of the whole—and ultimately when they got the complete contract they sold the cable they had laid, with their rights, to a company with whom his right hon. friend opposite arranged better terms.

The House divided, and the numbers were—for the amendment, 34; against, 199; majority, 165; after which the motion was agreed to.

COMPANIES' MEETINGS & REPORTS.

The India Rubber, Gutta Percha, and Telegraph Works Company (Limited).

An extraordinary general meeting of this Company was held on Tuesday, at the offices, 106, Cannon-street, E.C., Mr. S. W. Silver in the chair.

Mr. WM. J. TYLER (the secretary) having read the notice convening the meeting,

The CHAIRMAN said that this was a formal meeting to confirm the resolutions passed at the extraordinary general meeting, held on the 18th February. He would read No. 1:—"The Board of Directors may from time to time appoint one of their number or any other person to be a managing director of the Company, and may determine the amount of his remuneration and the terms of his engagement, but no such engagement shall be for a longer period than five years. A managing director shall not retire from office during the period of his engagement." He moved the confirmation of that resolution.

Mr. SCOTT seconded the motion.

Mr. CATOR said he saw by the last balance-sheet that the remuneration of the Board was a minimum of £2,000, and the extra was £2,695, giving to each of the four directors £1,173. If the number of directors were to be increased to seven, including the managing director, and if the remuneration were increased in the same proportion, then the remuneration of the directors would be the large sum of £6,874; and if the Managing Director were to receive more than the rest, then, of course, the sum would be much larger still, and would be much more than was paid to the directors of another similar company.

The CHAIRMAN said the answer was that the maximum was £5,000, according to a motion made some years ago, which would not in any way be interfered with.

The SOLICITOR said the amount could never exceed £5,000.

The motion was then put and carried unanimously.

The CHAIRMAN then moved the confirmation of the second resolution, viz.:—"The number of Directors (including any managing director) shall not exceed seven nor be less than four, and every Director shall hold at least 100 shares in his own name as the sole holder thereof. The Directors may from time to time appoint any additional Directors or Director, provided the number shall not exceed seven."

The motion was seconded by Mr. SCOTT and carried.

The CHAIRMAN moved the confirmation of the following resolution: "The remuneration of the Directors, other than a managing director, shall be, from time to time, determined by the members at the ordinary meeting, but any proposal for the alteration of the remuneration of Directors shall be deemed special business, requiring seven days' notice to be given thereof."

Mr. SCOTT seconded the motion, which was carried.

On the motion of the CHAIRMAN, seconded by Mr. SCOTT, the fourth resolution was also confirmed, viz.:—"The Directors may from time to time sell, lease, exchange, or otherwise dispose of and deal with all or any part of the property of the Company situated in France upon such terms and in such manner as they may think expedient."

Mr. CATOR asked if the £5,000 maximum remuneration included the salary of the Managing Director.

The CHAIRMAN: Oh, no, not at all.

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Mr. CATOR: Could you give us some notion of what the remuneration to the Managing Director would be?

The CHAIRMAN: You were not present at the general meeting.

Mr. CATOR: No, I was not, unfortunately.

The CHAIRMAN: That was gone into and discussed.

Mr. CATOR: Was it named?

The CHAIRMAN: No; the shareholders distinctly objected to it.

Mr. GRAY: I offered to tell them all about it, but they would not have it.

Mr. CATOR: Well, I think that is most extraordinary.

The CHAIRMAN: As a trading Company, it was considered inadvisable.

Mr. CATOR: I do not think myself there could be the slightest possible objection to such a thing as that being made known to the proprietary of a company. The more openly these things are declared to the Company, I think myself, the better. I do not see why anything should be kept a secret. You see, these questions cannot be opened without some trouble afterwards. Here is a distinct thing in your notice:—You guard yourselves by saying you must have seven days' notice, and I know from experience, belonging to a number of companies, what a difficulty there is in opening these questions again, and therefore it is far better to have the thing settled on the spot while we are all here than postpone it for disagreeables afterwards.

The CHAIRMAN: I think I may say that the subject was disposed of and decided at our meeting on the 18th ult.

The SOLICITOR: Not by the Directors.

The CHAIRMAN: Not by the Directors at all, but by the shareholders.

Mr. CATOR continued to remark that the remuneration to the Directors would be a very large sum to this Company. They did not pay as high a dividend as formerly, and the shares did not stand as high.

The CHAIRMAN said the business was concluded.

On the motion of Dr. SMALL a vote of thanks was passed to the Chairman and Directors, and the proceedings then terminated.

National Company for the Distribution of Electricity by Secondary Generators (Limited).

Report of the Directors to be presented at the third ordinary general meeting of the shareholders, to be held on Thursday, the 18th inst., at the offices of the Company, 18, Warwick-street, Regent-street, W., at twelve o'clock:—

The anticipation of a profitable business which the Directors ventured to express in the report presented to the shareholders at the general meeting held on the 9th February, 1885, is being realised. The seven months of 1883, and the whole of 1884, formed a period of preliminary work undertaken with a view to demonstrate the Company's system. The amounts expended on the trial installations on the Metropolitan Railway and at Turin, though large, seem to have been fully justified by results. The accounts submitted to the meeting show a profit of £4,570. 10s. 7d., after deducting all expenses. After writing off from this balance £574. 4s. 2d. for depreciation of plant and a proportion of preliminary and other expenses, there is a net balance of £3,996. 6s. 5d., out of which the Directors propose to pay a dividend on the Preferred shares at the rate of 10 per cent. per annum, from the respective dates of allotment to 31st December, 1884, which will absorb £2,207. 6s. 4d., leaving to be carried forward £1,789. 0s. 1d. An amount of £1,087. 16s., received from the Banque d'Escompte de Paris on 13th of February in this year, as balance of the guaranteed minimum for the year ending 1st Feb., 1885, does not enter into the 1885 accounts, although 11-12ths were really earned in 1885. The installation at the mines and works at Aschersleben, in Germany, has been in operation for a considerable period, and is being extended. The installations at Turin and Tivoli, though progressing satisfactorily, are less advanced. The profits of these works will appear principally in the accounts of the current year. The Directors, therefore, have pleasure in pointing to the fact that the profits for the current year have already a a considerable basis from matured business, while the prospect of new business is promising from several quarters. The Directors have pleasure in announcing the conclusion of a contract with Mr. George Westinghouse, jun., of Pittsburg, for the working of the company's patents in the United States of America. The character and position of Mr. Westinghouse justify the expectation of important results from this arrangement. As in the case of the Banque d'Escompte, Mr. Westinghouse guarantees a minimum annual return to the Company. The shareholders are probably aware that a gold medal was awarded to the Company at the Inventions Exhibition, South Kensington, "for the successful working out of a system of distribution of electricity by induced currents." The installation at the Grosvenor Gallery, undertaken by Sir Coutts Lindsay and Company, is not yet complete. In regard to this installation, the Company has no responsibility beyond the supplying of their apparatus. The successful opening of the installation at Tours, under the direct supervision of the chief engineer of the Company, has produced a marked impression in France, and promises to lead to a large employment of the system there. In order to enable the payment of the dividend now recommended, without crippling the resources of the Company, the Directors waive their claim to remuneration up to the end of 1885. The Directors believe the time is not far distant when a dividend on the Ordinary shares may be looked for; they base this expectation on the growing appreciation of the system by scientists and the public. Mr. D'Oyly and Sir J. Mackenzie, the directors who retire by rotation, offer themselves for re-election. In pursuance of Article 70, Mr. Gustav Dufresne was elected to fill the vacancy on the Board of Directors occasioned by the death of Mr. Le Fez. This appointment will be proposed for confirmation. Mr. J. H. Thornton, the retiring auditor, will be proposed for re-election for the current year.

The Telephone Company of Egypt (Limited).

Report of the Directors for the year ended 31st December last, to be presented at the third ordinary general meeting of the Company, to be held at the office of the Company, 14, Austin Friars, E.C., on Tuesday, the 16th inst., at 12 o'clock.

The Directors are glad to be able to state that the business of the Company has been very materially extended during the period under review. The profit and loss account, including the balance of £165. 3s. 6d. brought forward from last year, after providing for income tax and writing off a sum of £300 in reduction of capital for depreciation, exhibits an available balance of £3,210. 0s. 8d., out of which your Directors recommend the payment of a dividend at the rate of 5 per cent. per annum. This will absorb £3,017. 15s., and leave a balance of £192. 5s. 8d. to be carried forward. The dividend now payable has, in accordance with the Articles of Association, to be applied in the following manner, viz.:—2 per cent. in final payment of the cumulative preferential dividend of 7½ per cent. for 1883; 3 per cent. in part payment of the cumulative preferential dividend of 7½ per cent. for 1884; leaving 4½ per cent. for that year still due. In order, however, that the earings of the present and future years may be applied specially to the payments of dividends for those years for which the accounts are issued, an alteration of the Articles of Association is now contemplated. The following figures will show the increase that has taken place during the last three years of the Company's existence:—

	1883.	1884.	1885.	Increase in 1885.
Total number of subscribers in Egypt...	454	547	714	167
Gross revenue................	£6,400	£7,014	£8,650	£1,636

The full benefit of the increase for the past year does not appear in the accounts now published. The revenue accrued for 1885 being £7,584 against a present gross revenue exceeding £8,650. Recent advices from the manager give encouraging accounts of prospects generally. In accordance with the Articles of Association General Fraser, C.B., R.E., the Chairman of the Company, retires from the direction, but being eligible, offers himself for re-election. Messrs. Price, Waterhouse and Co., the auditors of the Company, also retire, but offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. March 10.		Business Done Week Ending March 10. Highest.	Lowest.
Anglo-American	34,	35	34⅜	33½
Do. Preferred	57,	58	57¼	56¾
Do. Deferred	10½,	11½	11 5-16	11
Brazilian Submarine	11⅜,	11⅝	11 7-16	11⅜
Cuba	10½,	11	10¾	10½
Do. Preference	17½,	18½	18½	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	11 13-16	—
Direct United States Cable	9½,	9¾	9 11-16	9⅝
Eastern Telegraph	11⅞,	12⅛	12⅛	11 15-16
Do. 6 per Cent. Preference	14,	14½	14¼	14
Do. 5 per Cent. Debentures, 1899	104,	107	105½	—
Eastern Extension	13,	13½	13 3-16	12⅞
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust	6⅞,	7⅛	7 1-16	6 13-16
Do. Preference	13½,	13¾	13 11-16	13 7-16
Great Northern	14⅞,	15¼	15 1-16	14⅞
Indo-European	35½,	36½	33	35½
Reuter's	6¾,	7¼	—	—
Submarine	200,	210	207	205
West India and Panama	¾,	1	⅞	—
Do. 1st Preference	9¼,	9¾	9½	9⅜
Western Brazilian	7⅜,	7⅝	7½	6 15-16
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	93,	102	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	15-16,	1 1-16	1	—
Oriental	3-16,	5-16	—	—
United Telephone	12½,	13	12 11-16	12 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3¼,	3½	3⅜	—
Do. (fully paid)	5,	5½	5⅜	—
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1⅝,	1⅞	1 13-16	1¾
Maxim-Weston	5-16,	7-16	—	—

MISCELLANEOUS.

Telegraph Construction	38,	39	39	38½
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	23

TRAFFIC RECEIPTS FOR FEBRUARY, 1886.

Companies.	Feb., 1886.	Feb., 1885.	Increase.	Decrease.
Cuba Submarine	2,750	2,730	20	—
Direct Spanish Telegraph	1,576	1,442	134	—
Eastern Extension	33,688	40,114	—	6,426
Eastern Telegraph	48,814	61,784	—	12,970

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NOTES.

INTERRUPTION OF CABLE.—*The Times* correspondent reports, under date March 16, that telegraphic communication is interrupted between Ava and Myingyan.

GERMAN UNION TELEGRAPH COMPANY.—This company announce a final dividend for the year 1885 of 4s. 3d. per share, making a total distribution of 10s. per share.

THE TELEPHONE AT PEMBROKE.—At the last meeting of the Pembroke Township Commissioners it was agreed that the Town Hall should be put in telephonic communication with the Exchange at a cost of £16. 10s.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended 15th instant are £2,892, as compared with £2,865 in the corresponding period of 1885.

ACCIDENT.—On Monday afternoon at Willenhall a man named William Miller, of Birmingham, was engaged fixing a telegraph insulator on the top of a building in the market-place, when he fell into the street below and died in a few minutes.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 12th inst. were £2,449, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE FOLKESTONE ART TREASURES EXHIBITION.—According to present arrangements, the National Art Treasures Exhibition at Folkestone will be opened on or about 7th May. The ceremony, it is expected, will be performed by the Prince and Princess of Wales.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.—A meeting of this institution will be held at 25, Great George-street, S.W., on Thursday, 25th inst., at 8 p.m., when the following paper will be read, "Electric Lighting by Means of Low Resistance Glow Lamps."

SUBMARINE CABLES.—For the purpose of securing certain bonds or debentures of the company, aggregating £600,000, or $3,000,000, the Commercial Cable Company has executed a trust deed of the franchises, rights and cables to Ernest W. Siemens and Johann C. L. Loeffler, of Berlin, Germany, and Westminster, England, respectively.

POST OFFICE EXTENSION.—The Post Office authorities intend to give every facility for convenient removal to those persons in the neighbourhood of St. Martin's-le-Grand whose premises are required for the Post Office extension. Some of the present occupiers will have the option of removing either at Midsummer, Michaelmas, or Christmas this year.

LIGHTNING.—Mr. W. McGregor sends us a pamphlet explanatory of a proposed new society, which is to deal with the protection of life and property from lightning. We are of opinion that at the present time there are enough societies in existence, and that any work in connection with lightning protection may be very well undertaken by some of the older societies.

OBITUARY.—The death is announced in Paris of M. Felix Seblanc, professor of chemistry at the Central School of Arts and Manufactures, gas analyst for the City of Paris, and vice-president of the Society for the Encouragement of National Industries, &c. M. Seblanc, who was for a long time the *collaborateur* of Dumas, was directly connected with some remarkable discoveries in chemistry, and was no mean electrician.

THE PAN-ELECTRIC SPECULATION.—Our American namesake is of opinion that free trade in telephones, should it be established, will not be of the slightest benefit to the people at large. Out of the million of inhabitants within telephonic speaking distance of New York City Hall, it is doubtful if 2 per cent. would pay even the Indiana legal rate of three dollars per month.

THE POST OFFICE TELEGRAPHS.—The *Manchester Courier* states that it is satisfactory to be able to say a word for the efficiency of the telegraph department of the Post Office. During the present winter there have been numerous snowstorms, and none of the "news" wires connected with the provincial newspapers have been interrupted from any cause, although in previous years one snowstorm was sufficient to inflict a large amount of interruption.

THE TELEPHONE IN LUXEMBOURG.—The Chamber of Deputies of the Grand Duchy of Luxembourg has decided that in addition to the telephone system which was opened in Luxembourg in October last, the whole of the towns in the Duchy shall be telephonically connected. The number of subscribers amounts at present to 120. The apparatus employed in the system is electro-magnetic throughout, and the lines are of phosphor bronze upon iron poles.

TOWN LIGHTING.—The electric light has recently been installed in Modane, a small town of 2,400 inhabitants, in Savoy. The motive power is furnished by the River Arc, of course by means of turbines. The dynamos, which are upon the Thury system, have been furnished by Messrs. Meuron and Cuenod, of Geneva. The lamps are Edison incandescent. It is announced that the municipality of Salzburg, in Austria, have decided to let a concession for the electric lighting of the town.

THE ELECTRIC LIGHT FOR STEAMSHIPS.—Following the wise example of the P. and O. and other large steamship companies, the Royal Mail Company has just had its steamship "Trent" fitted with the electric light, at Southampton. It is probable that the company will—provided that the present installation prove satisfactory—introduce the electric light on all the steamships under its direction. The substitution of incandescent lamps in place of the oil lamps now in use would undoubtedly add greatly to the comfort of the passengers.

INSURANCE.—The Scottish Economic Life Assurance Society sends us a communication respecting their method of dealing with the insurance of electrical engineers, discussed recently in our columns, but it will suffice if we refer intending insurers to the company for information. We have called attention to the disability under which electrical engineers have laboured. We are most emphatic in our opinion that the risk run by electrical engineers is no worse than that of other engineers, and no exceptional treatment is required in dealing with their insurance.

EARTHQUAKE SHOCKS ON THE CONTINENT.—A Reuter's telegram, dated Madrid, March 15, says:—A strong shock of earthquake was felt last night in the province of Granada, causing great alarm among the inhabitants. No damage was done in the capital, but it is reported that several villages have suffered to some extent. The shocks were oscillatory from west to east, and accompanied by a rumbling noise. Another telegram, dated Wiesbaden, March 15, says: A violent shock of earthquake was felt here at twenty-eight minutes past midnight.

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AN ECONOMICAL TELEPHONE SYSTEM.—The Supreme Court of Indiana has affirmed the decision of the Marion County Criminal Court in the case of the State against John E. Hocket, the issues involved relating to the law reducing the rentals of telephones in the State from five dols. to three dols. a month, with a corresponding reduction for services to other towns. The decision is that the law is constitutional, and that the extra charges above three dols. a month made by the company for alleged service, &c., are illegal, as by the word "telephone" the law meant all the appliances in connection with the service.

PORTLAND LIGHTHOUSE.—In the House of Lords on Friday night, Lord Colville of Culross called attention to the inferior nature of the light now exhibited at the north end of Portland Breakwater, and asked the First Lord of the Admiralty whether, considering the importance of Portland as a harbour of refuge, it was intended to replace the existing red light by one of greater power? The Marquis of Ripon replied that directions had been given to the harbour master to report fully on the character of the light, which was calculated to be visible at a distance of eight miles. He admitted fully the importance of having an efficient light at that place.

THE STREET LIGHTING OF CARNOUSTIE. — Intimation having been received by the directors of the Carnoustie Gas Light Company that they desired to withdraw from the arrangement made in 1862 for the lighting of the streets, a meeting of the ratepayers was held on Friday evening to consider what steps should be taken for lighting the street lamps in future. The agreement with the gas company was read and discussed, and Captain M'Corquodale, who occupied the chair, remarked that as before next winter the Police Bill now before the House of Lords would be law, and the circumstances might be naturally altered, he suggested that a committee should be appointed to attend to the interests of the inhabitants. This was agreed to, and an influential committee was elected.

ELECTRO-CHEMISTRY.—The current issue of the *Comptes Rendus* contains an interesting note upon the electrolysis of salts, relating principally to galvanoplasty. The experiments of M. Renard are borne out in several important points. In known solutions it is believed that the quantity of metal precipitated is proportional to the temperature. This proportion, however, would appear to increase in the inverse ratio to the density of the liquid. When the distance of the electrodes is successively doubled, the quantity of metal precipitated decreases in geometrical progression so long as the distance is less than 32 centimetres. Above this value the law is not applicable. When the two electrodes are identical the quantities of metal precipitated are proportional to the square root of their surfaces.

LIGHTING BY PRIMARY BATTERIES.—At the recent meeting of the National Electric Light Association in America, Mr. Allen V. Garratt said:—"A primary battery, capable of successfully lighting for a number of hundred hours a single incandescent lamp, or, if necessary, a score of them, is not an invention to be put aside as wholly insignificant. I speak conservatively when I say that it makes not only possible, but feasible, the electric lighting of a single house, a yacht, a parlour, or sleeping car, or even a man's own private carriage. It also places at the disposal of every physician and surgeon a light always ready and requiring but little care, with which he can explore the interior of the human body. I need not suggest other uses for such a light. They suggest themselves to every one. This is a field of electric lighting which is out of the reach of the dynamo machine."

BUCHAREST.—On Thursday, March 5, the first Court Ball was given at the New Palace. It may be remembered that we have from time to time mentioned the progress of the electric lighting being carried out under the supervision of Mr. Francis Jehl, by the Edison Company of Paris. The work was only completed on the day before the ball, so that no prolonged experiments could be made. The current for the lighting of the lamps is supplied from the machine house at the National Theatre, which has been illustrated in our columns. The total number of lamps in the New Palace is 928, in the Old Palace 466, making a grand total of 1,394 lamps. The lamps used are Edison 10-candle lamps. A table of their distribution will be given in our next number. At the ball the lighting was extremely successful and highly appreciated by the twelve hundred guests.

BRASS TAPED CORE.—An exchange says that in the submarine cable laid last year between Mozambique and Zanzibar the insulated core was protected by brass tape. This forms a complete protection against the teredo, which destroys the insulation of the cable. This type of cable is being much used where the teredo is found. Copper tape was used for some submarine cables many years ago, but not for the protection of the insulator. Its application for that purpose is recent, although the plan was patented nearly 20 years ago. Copper tape is also used for protection against land insects in some places where underground wires are necessary, all other methods to protect the insulation having proved ineffectual. Our contemporary is evidently not aware that the cables laid along the East Coast of Africa in 1879 were also brass taped in the same manner as the duplicate Zanzibar-Mozambique which is referred to—that is to say, brass taped as far as the intermediate sections and shore ends are concerned.

LOCAL AUTHORITIES AND TELEPHONE WIRES.—The Bill of the Nelson Local Board came before the Court of Referees, at the House of Commons, on the 8th inst., on the petition of the Lancashire and Cheshire Telephonic Exchange Company, for a *locus standi* to appear against the Bill. The sections of the Bill which affected the petitioners related to overhead wires, and empowered the Local Board to make, alter, or repeal from time to time bye-laws for preventing danger and obstruction to the public by posts, wires, and other telegraphic or telephonic appliances in or across the streets. Powers were also asked for the prohibition of such posts, wires, &c., unless upon conditions to be prescribed by the Local Board, and for the removal of such appliances already in existence, after a period of five years, if the Board should so determine. After some remarks by counsel representing the parties, the Court decided that, as Parliament was very jealous of local authorities obtaining such legislative powers as were sought by the Bill unless the parties affected were heard upon the petition, in this case the *locus standi* would be allowed.

RAILWAY CARRIAGE LIGHTING.—As our readers will be aware, the lighting of railway carriages by electricity is making great strides in France, and recently the Compagnie des Wagons-Lile have been carrying out a course of experiments under the direction of their engineer, Mr. Street, with the system recently invented by M. Lucien Desruelles, the results of which are said to have been of a satisfactory nature. The experiments have been principally carried out on the restaurant cars; each car is lighted by twenty-one incandescent lamps, of which nineteen are of 6 candle-power and two of 3 candle-power. These lamps, with the exception of the two last, which are grouped in series, are placed in multiple arc upon the terminals of the source of electricity, which, in this case, is a primary battery invented

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by M. Desrulles. Each of the elements weighs 14 kilogrammes and has an E.M.F. of 2·19 volts, giving on short circuit about 35 amperes. Its capacity is about 200 ampere hours. The 21 lamps in each car are supplied by a battery of 45 elements, 15 of which are connected in series and three in multiple arc; in average working the difference of potential at the terminals is 17 volts, and the current about 17 amperes.

THE ELECTRIC LIGHT IN NEW SOUTH WALES.—Messrs. J. and J. Hayes, of the City Steam Flour Mills in Goulburn, N.S.W., have recently introduced several important improvements in their mills. Amongst these is the electric light, the proprietors thus having the honour of first adopting in Goulburn this mode of illumination. The apparatus has been supplied by the Australasian Electric Light Company of Sydney, and has been fitted up by Mr. Barton, in their employ. The power for working the dynamo is communicated by a belt from the driving machinery of the mill. The dynamo, which is placed on the first floor of the mill, occupies hardly more space than a gasmeter, being only 2ft. 6in. long by 1ft. broad and 1ft. high. The dynamo is a Victoria-Schuckert, made by the Anglo-American Brush Electric Light Corporation. It is capable of supplying 40 lights; the number at present used is 20, for which about 3 horse-power is required. The lights are Swan's incandescent. They give a bright soft light; but their great recommendation in the present instance is their safety as compared with naked lights, the danger of explosion in the mill being avoided. This is the reason which chiefly induced the proprietors to adopt the electric light. The first trial of the light was made recently, and the apparatus is now in full working order.

THE ELECTRIC LIGHT IN MANUFACTORIES.—A contemporary has recently had the pleasure of seeing an electric installation in Messrs. Marsland's printworks, Cheadle, which had been carried out by the Manchester and District Edison Electric Light Company. The works lie some distance from the village of Cheadle, and are not supplied with gas, the lighting formerly being done by means of oil lamps, so that the present opportunity was a good one for either putting down a gas plant or an electric light installation; the latter plan has been adopted, and, all things considered, we do not doubt that it was the best thing to do. There have been put down about fifty Edison-Swan incandescent lamps, each of sixteen candle-power, the motor being one of Elwell-Parker's 10in. machines; one of Marshall's 6 horse-power vertical steam engines supplies the necessary power. The engine and motor are well finished and reflect credit upon their respective makers. The usual devices of fusible safety wires are inserted in each room, so that in the event of an excess of current passing through any portion of the circuit, say, from contact of the wires, the fusible part melts out and the lamps in that part of the circuit are cut off; in this way the fault is localised and can be readily found and remedied. Switch taps also are applied to each room, and the work has been done with that care so essential to the success of an electric light installation.

THE TELEPHONE FOR RIFLE MATCHES.—Lieutenant H. de B. Hovell has recently made some interesting experiments at Browndown with the view of ascertaining the utility of the telephone in connection with rifle-shooting matches. The tests have been made at the 600 yards range, where a wire was laid from end to end at the height of about 4ft. from the ground, so as to communicate from the shooting party to the marker behind the butts. The telephone apparatus was attached to two india rubber caps of a similar pattern to those used in her Majesty's ships for diving purposes, one of which was worn by a person at either end of the range. These caps are of a portable description, and can, of course, be attached or detached at pleasure. They comprehend in a very small space a transmitter and a receiver, and were found to act so well that conversation could be heard almost as distinctly as by means of an ordinary telephone. So far the experiment is pronounced to be a success. By its means the officer in charge of a firing squad would be afforded direct communication with the "marker," who in turn could telephone at once the result of each shot, and other additional information. The apparatus is comparatively inexpensive, and it is probable that it will be adopted almost immediately. It could always be ready for use, as the wires can be permanently laid, and the affixing of the other apparatus only occupies a few minutes.

TESTING CARBONS.—The following is suggested as a perfectly fair carbon test:—Take a dynamo machine, with its full complement of lamps, and trim the lamps with the same make of carbons; note the speed of the dynamo carefully, and during the test measure the current at frequent intervals with an ammeter; see that all the lamps burn freely, without hissing, and yet not with arcs so long as to flame. Measure the E.M.F. around each arc with a voltmeter. Burn the lamps until all the carbons are consumed, or burn them, say, for four hours, and then measure the length of carbons consumed, and calculate the total time that they would burn, taking the average result. In testing another make of carbon, pursue the same course. You will now be able to note the difference between various grades of carbons. Some carbons will be soft, and will consume so rapidly as to make them uneconomical; others will be of such high resistance that the machine will not run its full complement of lamps with good long arcs, without increasing its speed. In such a case, a lamp or two could be cut out of the circuit until the arcs are normal, and this would show the degree of economy of the first carbons over the others. It is not infrequently the custom to mix several different brands of carbons on the same circuit of lamps, and then judge of the results entirely by the length of time each carbons burns. Nothing could be further from a real test. A carbon which would burn nine hours would frequently be less economical than a carbon burning eight hours; as generally the latter carbon would enable you to burn, say, two more lamps on a thirty-light circuit than the former. Calculating the rental receipts from these two lamps it would be found that they would more than make up the difference due to more rapid consumption of the eight-hour carbons.

THE ELECTRIC LIGHT IN GERMAN UNIVERSITIES.—An agreement has been entered into between the German Government and the Edison Company in Berlin for the supply of electricity to the university in that city. The necessary works will be carried out during the coming summer holidays, after which the whole of the buildings will be lit by glow lamps and arc lights, to the entire exclusion of gas. The current will be supplied from the central station in No. 85, Friedrichstrasse, and will be used not only for lighting, but also for experimental purposes in the laboratories attached to the university. The primary object of this installation is to afford the Minister for Education in Germany an opportunity of satisfying himself on the applicability of the electric light to schools and other educational establishments; and if the verdict should be in favour of the new illuminant it will be introduced as a general thing in universities and schools. As a matter of fact negotiations are already pending with regard to the introduction of the electric light at the old and world-known university of

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Halle, and many others of the seats of learning will in due time follow. The observant English tourist, when travelling in Germany, has no doubt remarked what a large proportion of the students wear spectacles, and has been at a loss how to account for this. Whether the affliction of short-sightedness be due to want of outdoor exercise, or to the angular and indistinct character of German print, or to an excessive indulgence in beer and tobacco, as some uncharitable persons maintain, is a question we cannot pretend to answer. Certain it is, however, that with the introduction of the electric light, to the entire exclusion of gas, the affliction of short-sightedness will to a considerable extent be diminished, and at the same time the general health of students will increase.

Electric Lighting at the Leeds Town Hall.—Some time ago the Electric Lighting Committee of the Leeds Corporation resolved to illuminate the Victoria Hall by means of arc lamps, at a cost of about £450. It will be recollected that on the occasion of the last musical festival, in October, 1883, the hall was illuminated by means of incandescent lamps by Messrs. Crompton and Co. The "electroliers" have not been removed, and if the Musical Festival Committee should prefer the incandescent lamp to the arc lamp, they will be allowed to remain until after the Musical Festival in October next, when the Electric Lighting Committee will proceed to fix the arc lamps. Two arc lamps have been suspended in the hall, and the Electric Lighting Committee have had an opportunity of inspecting them. The experiment showed that no fault could be found with the steadiness of the light. There was no flickering or change in the brilliancy, and the committee were so satisfied with the lamps that they have ordered others to be fixed. The installation in its entirety will consist of eight arc lamps, driven by secondary batteries placed in the Municipal Buildings, and the remaining lamps, with the necessary wires, &c., are in readiness to be put up. The lamps, which are the Brockie Pell patent, are connected in parallel. They are of 2,000 candle-power each, and each lamp takes twelve amperes of current. The lamps are fixed upon pulleys, so that they may be varied in height up to 46ft., and the cleaning and renewing of carbons can be effected by a person standing in the body of the hall. E.P.S. batteries are used, of the L type, and their capacity is 500 ampere hours, which will give a ten hours' run for the complete installation. The secondary batteries, which are coupled upon two groups in parallel, are charged by dynamos which the corporation already have in the basement of the Municipal Buildings. These dynamos are compound wound, and are used to light the Public Free Library with incandescent lamps. The current is carried from the basement of the Corporate Offices to the Town Hall along a subway in Calverly-street, and thence into the false roof of the Victoria Hall, from which the arc lamps are suspended. The features of the installation, with which the committee are satisfied, are perfect steadiness of light, absence of noise, and duration of carbon. The lamps, batteries, &c., are supplied by Messrs. Rowbotham and Worsley, of Manchester, and the installation is being carried out to the designs and under the direction of Mr. Thos. Hewson, M.I.C.E., the Leeds Borough Engineer.

Telegraphic Charges.—A deputation from the Association of Chambers of Commerce, amongst whom were Mr. Lewis Fry, M.P., and Mr. J. D. Weston, M.P., recently waited upon the Postmaster-General to lay before him the views of the Chambers in regard to telephones, the registration of telegraphic addresses, and the International Conference. The deputation was introduced by Sir B. Samuelson, M.P. (President of the Association). Two memorials were presented praying for the reduction of the charge for registering addresses, and for a reduction or equalisation of the charges for telephonic communication. The Postmaster-General, in reply, said that the Post Office lost both in time and in money by the system of registered addresses, and the department, therefore, was not anxious to increase the number. The question of the charges for telephonic communication was one of great intricacy, and he did not feel at that moment competent to discuss the large question of the Government taking over the whole telephone management. At the request of the Postmaster-General (who was suffering from a cold), Mr. Patey stated that the result of the International Telegraphic Conference was that the telegraphic rate to India would be reduced from 4s. 7d. to 4s. a word, to Russia from 9d. to 6½d., to Spain from 6d. to 4½d.; and reductions would also be made to other European States and to Australia, and probably other countries in the far East.—The Postmaster-General has recently been memorialised from Yorkshire to reduce the amount charged for the registration of telegraphic addresses from £1. 1s. to 5s. His lordship has replied that the actual cost the department incurs in respect of each registration considerably exceeds the sum of 5s., and that any balance that may remain out of the charge of one guinea is far from being sufficient to meet the loss of revenue arising out of the reduction in the number of words in telegrams which is brought about by the use of an abbreviated address. Apart from the question of expense, the letter states further that the use of abbreviated addresses causes delay, owing to the additional processes having to be gone through in discovering the proper place to which to send the message. If the fee for registration were reduced, the department would be taking a step which would lead the public to believe that the registration of abbreviated addresses was desirable, and a large increase in the number of registrations would probably take place. Lord Wolverton does not think that the department would be acting rightly in taking such a step. In former years abbreviated addresses were used almost solely for foreign telegrams, and the number of registrations was extremely limited; but the system is one which the department could never recommend to the public, and his lordship considers that it would be contrary to his duty to do anything which would encourage any great extension of the system.

A New Torpedo.—The Paulson torpedo system consists in the use of chemically-generated gas, which is utilised either for forcing a column of water direct astern, or for causing it to actuate machinery for driving a propeller. The explosive charge consists of a species of gun-cotton possessing 50 per cent. more power than ordinary gun-cotton, but having an equal degree of safety. The steering device is that upon which Mr. Paulson is most communicative, and this is stated to consist of two batteries, one pole of each of which is placed in connection with the coils of two sets of electro-magnets, from which leads are conducted to two metal pins fixed on a disc of insulating material. Both the other poles of the batteries are placed in communication with a balanced magnetic needle of special construction. The metal pins are placed one on either side of the needle, and the course of the torpedo having been set it is started. Any deviation of the torpedo from its assigned course causes a relative movement of the needle, which touches one or other of the pins, thus establishing the circuit through the coils of one or other of the two magnets. An armature connected with the rudder is attracted, and by this means the torpedo is again placed on its right course. The depth of immersion of the weapon is also regulated and main-

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tained in a similar manner by a vertically balanced needle. Another feature is that the torpedo can be directed towards iron ships, irrespective of the pre-determined course, by means of another balanced needle. A demonstration of the steering powers of the apparatus was recently given by the inventor at 15, Cockspur-street, Charing-cross, a model torpedo about 2ft. 6in. long and 7in. in diameter being used. The model was not placed in water but was swivelled on a stand, and it was clearly shown that when it deviated from the course upon which it had been laid, the electro-magnetic arrangement—which was of course concealed within the torpedo—came into operation and restored it to its normal course. More could not be shown, but it was stated that a full-sized torpedo, 16ft. in length and 14in. in diameter, had been made and successfully tried on the coast in England. On the last occasion, however, the torpedo had managed to get away from its inventor and had been no more seen. The material of which Mr. Paulson proposes to construct the shell of his torpedo differs from that hitherto used in that it is a species of papier-maché of a tough and fibrous nature. The new weapon is to be discharged from the shore or from any ordinary boat, thus obviating the cost of a special torpedo-boat. This feature points it out as valuable for coast and harbour defence, for which purposes it is the opinion of several naval authorities by whom it has been examined that it is especially adapted. In view of its apparent merits it would appear desirable that the Government authorities, who have had the matter under consideration for some little time past, should lose no time in constructing a torpedo of the proper working size and having it practically tested. This course is the less objectionable seeing that the cost is stated to be only about £150. At any rate the invention appears to justify prompt and thorough investigation in order that its practical usefulness or otherwise may be ascertained.

The Electric Lighting Act.—In view of the second reading of the Bill introduced by Lord Rayleigh to amend and extend the Electric Lighting Act, 1882, a report has been presented by the committee appointed to consider the matter at the instance of the President of the Board of Trade. The committee have arrived unanimously at the conclusion that the electric light companies should demand to be put simply in the same position as the gas companies are, both as regards their privileges and their obligations, inasmuch as they believe no satisfactory solution of the question of general electric lighting can be arrived at by amending the Act on the basis of a modified purchase option clause, and the conclusion itself is clear and intelligible, and will commend itself to the public by its fairness and simplicity. Electric light companies may safely undertake the business of general lighting under conditions entirely similar to those of the gas undertakings, and the committee have prepared the draft of a Bill, which Lord Rayleigh will present to Parliament. While unable to accept any purchase-option clause, the committee think it quite right that all reasonable facilities should be given to local authorities to acquire electric lighting undertakings by agreement. The committee says:—"Amongst other things it is to be remembered that as electric lighting develops and advances in popular estimation, a large and increasing capital will be necessary to extend the system and make the supply still cheaper and more popular. This will be the critical period; and the ultimate success of electric lighting may not be attained until a large portion of the term of the purchase option clause has expired. It is impossible that the new capital can in the remainder of the term earn a fair commercial profit, as well as the means of providing a sinking fund for replacing the loss. The price loaded with the cost of providing a sinking fund would be prohibitive to extended consumption. Any proposed extension of the enterprise at such a time must necessarily be a failure, commercially; the undertakers would be unable to obtain fresh capital in the market; and if there remained any uncalled capital already subscribed, the calls could only be made by a cruel injustice to the shareholders. If electric lighting undertakings are put on a footing of equality with gas, central station lighting will at least be tried on a scale sufficient to make the competition with gas serious. The executive committee believe that such undertakings will, through difficulties, achieve ultimate success. The possibility of electric lighting as a large and popular industry now hangs in the balance, and if the committee should adopt our recommendation to demand that the electric lighting industry shall be put on the same footing as gas, we think it fair that the argument should be respectfully urged on the Board of Trade, that if this reasonable demand is not conceded, upon them will rest the responsibility for the failure of electric lighting in this country, and for the far-reaching consequences which may follow such failure. How far these consequences may extend we cannot presume to speculate. Even at the present moment we believe that the stimulus given to genuine enterprise in electric lighting by putting it on the gas footing would be considerable. If that enterprise succeeds, a further stimulus will be given to the application of science to industry which cannot but be important. Indeed, the encouragement of electric lighting at the present moment might be the turning point in the long-continued depression of trade under which the country has lately been suffering. Having regard to the keenness of competition which has now overtaken the long undisputed lead of this country in industrial progress; having regard to the circumstance that England is already distanced by America in the industry of electric lighting; that this may be a step towards leaving to America a permanent lead in the new applications of science; and that America still holds in reserve the resources of the approaching extinction of her debt and the ultimate adoption of free trade, we think the Board of Trade will attach due weight to the importance of giving at this critical stage a fair field to the development of electric lighting enterprise. With these larger considerations the committee are not primarily concerned. As representing the interests vitally affected, the question for the committee is on what terms we can call for or invite capital to the enterprise of public electric lighting. We must keep in view that the electric lighting industry will in any case remain in possession of the smaller and safer field which may be exploited on conditions not involving wayleaves through the streets. The Electric Light Companies will continue in possession of the ship lighting industry, and on land they will be able to conduct electric lighting on a small scale as an expensive luxury for those who are able to pay for it. As to the larger field, if the industry can be worked only on the terms that property, which is the result of private money and enterprise of the undertakers — not consisting of an undertaking built upon land the subject of a concession, but as much their own as the property of an insurance company or telegraph construction company, which has been obliged to apply to Parliament for powers affecting its constitution—is to be taken from them by the local authority without either a fair bargain or an Act of Expropriation by the Legislature of the day, we, as representing those whose capital is proposed to be at risk, feel bound to pronounce the words *non possumus*. We cannot, we dare not, we will not embark our capital on these terms."

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ECONOMY IN ELECTRICAL CONDUCTORS.*

BY PROFS. W. E. AYRTON, F.R.S., AND JOHN PERRY, F.R.S.

(Concluded from page 355.)

V. For the purpose of constructing a table to be used for determining the proper current and resistance of conductor per mile to be selected in various cases in order to obtain maximum economy, and for determining the waste that will occur per mile in heating, and the amount of interest on the value of the copper per mile when the current and resistances per mile are employed, let

$$\frac{n\,t}{V} = \tan\phi,$$

then
$$C = \frac{P}{V}(1+\sin\phi) \quad . \; . \; . \; . \; . \; . \quad (11)$$

and
$$r = \frac{V^2}{n\,P} \cdot \frac{\sin\phi}{(1+\sin\phi)^2} \quad . \; . \; . \; . \quad (12)$$

Using these values, the following table (No. 1) has been calculated for V equal to 200 volts and P equal to 20,000 watts, in order to illustrate the way in which the current, sectional area of the conductor, and current-density proper to be used to obtain maximum economy, vary with the length of the line. The first column gives n the number of miles, at the end of which this power is to be furnished if the earth be used as the return. If the earth be not used as the return, then n will be *twice* the distance between the two ends of the line. The second column is $\frac{n\,t}{V}$, where t is taken as (17). The third and fourth columns give ϕ and $\sin\phi$, the fifth and sixth the current C in amperes that should be employed, and the resistance r in legal ohms per mile that should be given to the conductor to obtain maximum economy. Column 7 gives the sectional area A of the conductor in square inches, the resistance of one mile of copper wire of 98 per cent. conductivity at 20° C., one square inch in section, being taken as 0·04378 legal ohm. Column 8 gives D the current density—that is, the number of amperes per square inch. Columns 9 and 10, P_1 the power in watts wasted in heat per mile, and P_2 the watts wasted per mile as interest, including depreciation on the value of the conductor. The last column contains the values of P_3 the total rate of waste in watts per mile.

TABLE I.—To furnish 20,000 watts at the end of n miles.

1	2	3	4	5	6	7	8	9	10	11
n	$\frac{17}{200}n$	ϕ	$\sin\phi$	C	r	A	D	P_1	P_2	P_3
·1	·0085	0°29′	·0084	100·8	·1652	·2651	380·2	1679	1749	3428
·5	·0425	2°26′	·0425	104 3	·1564	·2800	372·5	1699	1847	3546
1	·085	4°52′	·0848	108·5	·1441	·3038	357·2	1695	2005	3700
2	·17	9°39′	·1677	116·8	·1229	·3563	327·8	1675	2351	4026
4	·34	18°47′	·322	132·2	·0921	·4753	278·1	1609	3137	4746
6	·51	27°2′	·4545	145·5	·0716	·6115	238 0	1514	4036	5550
8	·68	34°13′	·5623	156·2	·0575	·7614	205·1	1403	5026	6429
10	·85	40°22′	·6477	164·8	·0477	·9179	179·5	1295	6058	7353
15	1·275	51°54′	·7869	178·7	·0328	1·335	133·9	1047	8810	9857
20	1·7	59°32′	·8619	186·2	·0241	1·817	102·5	835	11911	12746
30	2·55	68°35′	·931	193·1	·0166	2·637	73·2	618	17530	18148
50	4 25	76°46′	·9735	197·4	·0099	4·423	44·6	385	29191	29576
70	5·95	80°27′	·9861	198·6	0071	6·166	32·2	280	40704	40984
100	8·5	83°18′	·9932	199·3	·0049	8·935	22·3	194	58979	59173

The latter portion of this table has been calculated merely for the purpose of illustrating how the current, sectional area of the conductor, and current-density necessary to be used to obtain maximum economy, vary with the length of the line, and not because anyone would think of attempting to transmit 30 horse-power 50 or 100 miles with a potential difference of only 200 volts at the dynamo.

The problem considered by Sir William Thomson led to the result that in order to obtain maximum economy the area of the conductor depended solely on the current, and was independent of the length of the line, or, in other words, the current-density was a constant. But from the preceding table we see that, *if a given amount of electric power has to be furnished at the end of a line with a given potential difference at the dynamo, maximum economy is obtained, not by keeping the current-density constant, but by making it diminish as the length of the line becomes greater.*

In order to employ this table for other amounts of power to be furnished at the distant end of the line, it is to be observed that since

$$C = \frac{P}{V}(1+\sin\phi) \quad . \; . \; . \; . \quad (13),$$

$$r = \frac{V^2}{nP} \cdot \frac{\sin\phi}{(1+\sin\phi)^2} \quad . \; . \; . \; . \quad (14),$$

and since the sectional area of the conductor

$$A = \frac{0{\cdot}04378\,nP}{V^2} \cdot \frac{(1+\sin\phi)^2}{\sin\phi} \quad (15),$$

it follows that with the same initial potential difference the most economical current to employ is directly proportional to the power to be furnished at the distant end, the most economical resistance per mile to give to the conductor is inversely proportional, and the most economical sectional area directly proportional to the power that has to be furnished at the distant end of the line.

VI. In the construction of telpher lines we use steel rods both to carry the load and to carry the conductor. In order, then, to see how the numbers in Table I. must be altered if steel be used, instead of copper, we must see how the value of t is altered. Now, since

$$t^2 = 67{\cdot}84\,\frac{i \times c \times \rho}{p}$$

where i is the yearly interest, including depreciation, on money invested in conductors, c the value in pounds of a ton of the metal used in making the conductor together with the value of the necessary amount of insulation, ρ the resistance of a wire one mile long and one square inch in section of the material employed in making the conductor, and p the annual cost in pounds of an electric horse-power for the number of hours that power is required. Now, the specific resistance of steel bears to the specific resistance of copper approximately the inverse ratio of the cost per ton of steel to the cost per ton of copper; hence the product $c\,\rho$ for steel will be roughly the same as $c\,\rho$ for copper, and consequently the value of t may, for a rough approximation, be regarded as unaltered. All the columns, therefore, in Table I. will remain roughly the same if steel be used in the place of copper, with the exception of column 7, giving the sectional areas, and column 8, the number of amperes per square inch.

Also all the columns will remain unaltered as long as $\frac{i \times c}{p}$ is constant; for example, no change will be necessary if the yearly interest, including the depreciation, be taken as £10 instead of £15, and if the yearly value of an electric horse-power be also taken as £10 instead of £15.

VII. We may take as an example of the use of the results obtained by this investigation the case of the electric transmission of power from Paris to Creil by M. Deprez. The distance is 37½ miles, and as a wire was used for both the going and return conductors n equals 75; the potential difference at the dynamo V was about 5,600 volts, therefore

$$\tan\phi = \frac{n\,t}{V}$$
$$= 0{\cdot}2278$$

or
$$\phi = 12°\ 50'.$$

Hence, as the power furnished at the distant end of the line, P, was about 30,000 watts.

$$C = 6{\cdot}549 \text{ amperes},$$

and
$$r = 2{\cdot}073 \text{ ohms}$$

give the values of the current and the resistance per mile of the line that should be used to give maximum economy, or since

* Paper read at the Meeting of the Society of Telegraph-Engineers and Electricians, March 12th.

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the line is ·75 millimetre long, the total resistance should equal 155·5 ohms.

M. Deprez actually used a current of about 7·2 amperes, and the total resistance of his line was 100 ohms. We do not know on what principle he calculated the size to give to his conductor, which was a copper wire five millimetres in diameter, but the current conveyed was at the rate of about 36·6 amperes per square centimetre. The above, however, shows that the most economical current, using 17 for the value of t, would have been at the rate of 47·7 amperes per square centimetre. But as his object was rather to show economy in electric transmission of power, irrespective of first cost, than to show economy in copper used, and as when he began his experiments he was probably not quite sure of the potential difference at which his dynamo would give out electric power, we think that he was quite right in using a thicker conductor than our calculation shows would have produced the minimum total waste.

We have already seen that when we have to supply a given amount of electric power at the end of a certain line, using a given potential difference at the dynamo, the current-density to be employed to obtain maximum economy diminishes as the length of the line increases. Thomson's rule for the current-density is obtained from his equation for maximum economy—

$$C = \frac{t}{r},$$

and the equation

$$A = \frac{0{\cdot}04378}{r}$$

$$\therefore D = \frac{t}{0{\cdot}04378},$$ which is independent of the length of the line.

For t equal to 17 his D equals about 393 amperes per square inch. We see, therefore, that this current-density exceeds that given for all the lengths of line, even for the shortest—0·1 mile or 170 yards—in column 8 of Table I., although in calculating this table the same value was employed for t; that is, the same values were used for the yearly rate of interest, for the price of copper wire per ton, with its necessary insulation, and the same cost per year for an electric horse-power for the number of hours power is required. In order to see whether for any distance, or for any amount of electric-power to be supplied at the end of this distance, it is economical to use so large a current-density as is given by Thomson's rule, we will find an expression for our current density. Dividing the expression given for C in (13) by that for A in (15), we have

$$D = \frac{V}{0{\cdot}04378\,n}\,\frac{sin.\,\phi}{(1 + sin.\,\phi)};$$

hence, as

$$tan.\,\phi = \frac{n\,t}{V},$$

$$D = \frac{V}{0{\cdot}04378} \cdot \frac{t}{n\,t + \sqrt{n^2 t^2 + V^2}} \quad . \quad . \quad . \quad (16)$$

Now this is independent of P, the number of watts to be supplied at the end of the line; hence all the values of D, in column 8, Table I., being smaller than the current-density given by Thomson's formula for maximum economy has nothing to do with the amount of power that is to be supplied. Further, we see that the value of D in (16) can only equal $\frac{t}{0{\cdot}04378}$, the value of D given above by Thomson's formula, when either V is extremely large or n extremely small. Hence we may conclude that *in all problems connected with the electric transmission of power where the maximum potential difference that we may use is fixed for us by the Board of Trade, or otherwise, a smaller current-density than that given by Thomson's formula must be used to obtain maximum economy, and the longer the line the smaller must this current-density be; also, the smaller the maximum potential difference that may be employed, the smaller must the current-density be to obtain maximum economy.*

VIII. We have discussed at some length the conditions of maximum economy when a given amount of power has to be supplied at a given distance with a given potential difference at the dynamo, on account of its wide practical importance; but there are many other practical cases which we have not thought it necessary to discuss in which there is an initial relation connecting C and r. One example may, however, be referred to.

Let there be a level electric railway extending n miles in one direction from the engine-house, on which one train is running requiring P watts to propel it at a uniform speed of v miles per hour. Let the resistance of the conductor conveying the power from the dynamo to the train be r ohms per mile, and let V be the constant potential difference at the dynamo. At a time (τ) reckoned from the time the train is at the engine-house let it be at a distance x miles along the line, then

$$P = C\,(V - C\,x\,r),$$
$$x = v\,\tau,$$
$$d\,x = v\,d\,\tau.$$

When the train is at a distance x the rate of wasting power, in watts, is

$$C^2 x r + n\frac{t^2}{r};$$

therefore the waste, in joules, in a time $d\,\tau$ is

$$\left(C^2\,x\,r + n\frac{t^2}{r}\right) d\,\tau;$$

hence the loss in the whole line n miles long is

$$\frac{1}{v}\int_0^n \left(C^2\,x\,r + n\frac{t^2}{r}\right) d\,x,$$

and maximum economy will be effected by selecting C and r so that this expression is a minimum when C and r are connected by the first equation given above.

IX. Hitherto we have been dealing with a conductor giving off power only at one point—either at its end, or, as in the last problem, at a point the position of which varies from time to time; but in telpherage, and in many systems of electric lighting and transmission of power, we have to deal with a conductor giving off in every mile the same amount of electric energy; which, bear in mind, does not mean giving off the same amount of current per mile, since there is a diminishing potential difference as we proceed along the conductor from the dynamo. This problem we deal more fully with in another paper. But if we suppose that an independent conductor takes the required supply of energy to every short length of line—that is, if a number of feeders are employed—we can at once use the results that we have already obtained to determine the most economical amount of copper to employ.

Having determined the most economical size of separate conductor to convey the power to each point of the line of distribution, we may for practical purposes imagine all the conductors connected together metallically so as to form a tapered conductor. As, however—if we imagine such a metallic joining together of the separate conductors—currents will flow through the connections, because the potentials at a point where a connection is going to be made differ from one another in the various conductors, it follows that a conductor of the aggregate section of all the small conductors at every place will not be as economical as would be a conductor whose section at every place was independently determined from the considerations which are given by us in our other paper. However, taking the section of the tapered conductor to be equal to the sum of the sections of the separate conductors which distribute the energy with maximum economy, we find that the following is the result:—

Let the section of a conductor to transmit with maximum economy P watts n miles with a given potential difference be called

$$P f(n);$$

then

$$\int_x^{x_1} P f(x)\,d\,x$$

is the aggregate section at a point x miles from the dynamo when the end of the line is x_1 miles from the dynamo. It is easy to obtain an exact integral, using (15) for $P f(x)$, but we have preferred to integrate from a curve giving the value of A or $P f(x)$ when P is 20,000 in column 7 of Table I.

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In this way we have, for illustration, calculated Table II., which gives the most economical sectional area, in square inches, at the end of each mile when the conductor *tapers* according to the law just mentioned; it is calculated for a potential difference of 200 volts at the engine house, and for a power of 5,000 watts given off in every mile. The four horizontal rows give the sectional area, in square inches, of the tapered conductor at the end of each mile, when the total length of the conductor is respectively 3, 5, 8, and 10 miles.

TABLE II.

Total Length of Conductor from Engine House, in miles.	Area, in square inches, of the Tapering Conductor at the end of										
	0	1	2	3	4	5	6	7	8	9	10 miles
3	0·24	0·17	0·09	0							
5	0 47	0·40	0·32	0·23	0·12	0					
8	0·94	0·88	0·79	0·70	0·60	0·47	0·33	0·18	0		
10	1·35	1·28	1·20	1·11	1·00	0·88	0·74	0 58	0·41	0·21	0

Table III. gives the current, in amperes, flowing through the conductor at the end of each mile in each of the various cases described above.

TABLE III.

Total Length of Conductor from Engine House, in miles.	Current, in amperes, flowing through the Tapering Conductor at the end of										
	0	1	2	3	4	5	6	7	8	9	10 miles
3	85·7	59 6	31·4	0							
5	151·8	125·7	97·5	66·1	34·0	0					
8	262·9	236·8	208·6	177·2	145·1	111·1	75·5	38·4	0		
10	343·2	317·1	288·9	257·5	225·4	191·4	155·8	118·7	80·3	40·7	0

Table IV. gives the current-density at the end of each mile in each of the cases described above.

TABLE IV.

Total Length of Conductor from Engine House, in miles.	Current Density in the Tapering Conductor at the end of										
	0	1	2	3	4	5	6	7	8	9	10 miles
3	357·2	350·5	348·9	0							
5	322·9	314·2	304·7	287·4	283·2	0					
8	279·7	269·1	264·1	253·1	241·8	236·3	228·8	213·3	0		
10	254·2	247·7	240·7	232·0	225·4	217·5	210·5	204·6	195·8	193·8	0

Here again, then, the current-density proper to be used to obtain maximum economy is not constant. It not only diminishes as we go further along the tapered conductor, but at any one point is the less the greater the total length of the line.

A THERMOPILE AND GALVANOMETER COMBINED.*

BY PROF. GEORGE FORBES, M.A.

The author has lately made use of a special form of thermopile and galvanometer combined, which is very sensitive for the measurement of radiation. The apparatus is especially suitable for use as a line thermopile.

The first experiments were made with two half tubes, one of antimony the other of bismuth, soldered together so as to make a short tube about 2 cm. external diameter, the walls being 2 mm. thick, and the length of tube about 2 or 2½ cm. The sides of the tube where the junction of the metals occurs was then filed flat, so as to present a thin wall to receive the radiations and to enable it to rise in temperature more rapidly, and also more uniformly throughout the thickness of this wall. This tube was lamp-blacked. A Thomson mirror and magnets (by J. White, of Glasgow), in its usual brass cell, but with an insulated coating, was then inserted in the tube, and the whole apparatus mounted inside a brass cube with a brass cone at one side to throw the radiations upon one junction, and with a circular hole facing the mirror. This apparatus, when properly adjusted with a lamp and scale was found to be very sensitive. It had been the intention of the author to use a telescope in place of a lamp, but the radiations of the lamp were found to give rise to no inconvenience.

Let us compare the probable sensitiveness of this instrument, say, with a line-thermopile of the ordinary construction of 20 pairs, forming a line of the same length as the tube, the double length of a pair of antimony and bismuth in the line-thermopile being equal to the circumference of the tube. Let E be the E.M.F. of one junction, and let R be the resistance of one pair in the line-thermopile, and let R′ be the resistance of the galvanometer used with the line-thermopile. The total resistance of the line-thermopile is 20R, and that of the tubular one is $\frac{R}{20}$, and the currents in the line and tubular thermopiles respectively are $\frac{20\,E}{20\,R+R'}$ and $\frac{20\,E}{R}$. If the galvanometer were specially constructed to match the line thermopile R′ would be made equal to 20 R, and the current would be $\frac{E}{2}$, or one-fortieth of the current in the tubular thermopile and galvanometer combined. Thus it would require forty turns of wire in the low resistance galvanometer, if these coils occupied the same space as the metal of the tubular thermopile, to equal the sensitiveness of the latter, and a larger number if it occupied a greater space. On the whole, it seems probable that by specially designing a galvanometer to match the line thermopile the arrangement would be about as sensitive as the new instrument in the form hitherto described, but the simplicity and cheapness of construction of the latter commends it.

The next apparatus was made according to the following instructions :—

Take a wedge whose distance from the apex to the base is about 6 cm., the base of the triangular section of the wedge being about 3 cm., and the width of the wedge 6 cm. The wedge is half of antimony and half of bismuth, the division being made by the medial plane perpendicular to the three rectangular faces of the wedge cut off the apex of the wedge by a plane parallel to the base of the wedge, and exposing a surface of 1½ cm. width. This is the surface which receives the radiations, and it is lamp-blacked. A hole about 1 cm. diameter is now drilled (or it is better to file it out before the two metals are soldered together) through the two sides of the wedge, so as to leave only a thin wall along the junction of the metals at the surface which receives the radiations. A Thomson cell with suspended mirror and magnet is inserted in this hole and the instrument is complete, and ready to be placed inside the brass box with cone already described.

The resistance of this cell is very low, and its sensitiveness thereby increased. Moreover, this type has a great advantage in the fact that the mass of metal acts as a damper upon the vibrations of the magnet, and so we have a dead-beat instrument.

The diameter of the cone to receive radiations at its mouth was 5 cm. A candle at a distance of 30 cm. from the mouth of the cone gave a deflection of 52 divisions, a reading being easily made correct to one division. A duplex lamp burning paraffin oil at a distance of 1½ metres gave a deflection of 60 divisions.

The author takes this opportunity to describe a method of carrying the delicate Thomson cells without danger of breaking the silk fibre suspension. The cell consists externally of a brass tube. A horse-shoe magnet is obtained with the distance between its legs small compared with the diameter of the above-mentioned tube. The tube is so placed as to rest on the inner edges of the legs of the magnet, with the mirror over the poles of the magnet, the mirror magnets having their poles over poles of opposite name of the horse-shoe magnet,

* Abstract of a Paper read before the Royal Society.

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and with the silk fibre next to the magnet. The mutual magnetic attraction takes the tension off the silk fibre and holds the mirror fixed in position, and the fibre cannot be broken by a blow given to the apparatus.

CORRESPONDENCE.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As the etiquette of journalism which prevents your courteous reviewer from revealing his identity does not prevent him from explaining his reasons for differing from the corrections which I have given to his remarks, I presume that the same useful etiquette will not debar him from reading my reasons for adhering to my corrections. As he has gracefully acknowledged his error in respect of the number 746, I may pass over without serious protest his irrelevant excuse that it was not until after Lord Rayleigh's investigations that we could rely upon the substantial correctness of horse-powers calculated from observations of volts and amperes by use of the denominator 746. That latter statement I do not dispute, but once more repeat that it has nothing whatever to do with the original and incorrect statement of my reviewer; the right figure should be 736.

I must, however, seriously protest against the rest of your reviewer's letter on page 353, in which he persists in using the term critical speed in another sense than that in which it is used by all the authorities who have written on the subject. I pointed out on page 331—though apparently all too briefly for the clear apprehension of the matter—that the definition of the critical speed of self-regulation must not be confused with the speed at which a self-exciting dynamo is just able to excite itself (with given resistances in its circuits). Your reviewer persists that the term "critical speed" is correct for the latter, not for the former. I beg most politely, yet firmly, to persist that the term critical speed, as used consistently by me, by M. Marcel Deprez, by Professors Ayrton and Perry, and I believe by every competent writer on the question of compound winding, is used in the sense of the speed that is critical for self-regulation, and *not* in the sense of the speed that is the limit for self-excitement. Of course, if your reviewer is right, then no machine that is not purely self-exciting can have a critical speed, be it motor or generator. It follows, as a matter of course, from the definition, if your reviewer's definition is right; but, unfortunately it is not! Give a definition a wrong turn, then hang the writer who dares to write the right one. This persistent perversity of using a wrong definition has led your reviewer in his defence into a strangely wrong-headed argument. He seriously argues about a sentence of mine as if the machines I mentioned in it as having permanent magnetism or separate excitement were not self-regulating machines at all, whereas I mentioned machines having such auxiliary excitement as instances of machines having certain critical speeds for self-regulation, and yet not depending on any limiting speed before their magnets are excited. Your correspondent seizes upon my words, oblivious that the whole thing relates to self-regulation, and jumps to the conclusion that I referred to certain magneto or separately excited machines that are not self-regulating, and which have no critical speed either in his incorrect sense or in the correct sense of the word. Hence follows all his muddle about the want of parallelism between a descending curve of potential and an ascending line of resistance, and his triumphant proof that the descending curve cannot possibly be parallel to the ascending line. Of course, it cannot; and it has absolutely nothing to do with the point at issue, simply because the descending curve about which he talks is not the curve of a self-regulating machine at all! I have shown on page 372 of my book that for a pure self-exciting series-wound dynamo there is no such thing as a critical speed, independent, like the true critical speed of a self-regulating dynamo, of the resistance of the external circuit. I have shown, on p. 382, how, at the critical speed, the characteristic curve of the self-regulating (constant-potential) dynamo (whether its initial excitement be due to the magneto machine or to the separately excited coils combined with the series coils) not only is but must be approximately parallel to the sloping line that represents (by the tangent of the angle) the armature resistance. This is a hard saying; it has "stumbled" your reviewer; it will stumble him again if he sets out with the wrong definition, even though it is carefully explained with the help of two illustrative cuts on pp. 382 and 383, and the similar case for constant-current machines by a third cut on p. 385 of my book. I know that my book is dull and tedious and long-winded, and I can well pardon a reviewer who should skip a little when he reached the 382nd page. Only he should not afterwards turn round and beg to be told how a curve (and the mathematical term "curve" includes those whose equations are *of the first degree*) can be approximately parallel to a given straight line. If he will ask me to show him how the curved sole of my boot can be placed approximately parallel to the horizontal plane, I shall be happy to oblige him.—Yours, &c., SILVANUS P. THOMPSON.

Finsbury Technical College, March 14th, 1886.

P.S.—About the motors. Your reviewer does not understand that *if* a constant current is driven through a motor the potentials at the terminals of the motor will vary with its speed, and may be made, therefore, to regulate that speed by use of a shunt winding properly proportioned to the case. He says: "If my (that is to say, his own) views on critical speed be right, special, and probably complicated, regulating apparatus will have to be added to each motor." Exactly so. I have no doubt of it. S. P. T.

SECONDARY BATTERY INDICATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have carefully read Mr. Sellon's specification, as given in his letter in your last issue, and must say, with all due deference to that gentleman's valuable inventions, that I fail to see how it anticipates the perfected arrangement patented by Mr. Parker in 1884. In the first place, ascertaining the state of the charge in secondary cells by measuring the specific gravity of the liquid had, we all know, been suggested and practised before the date of Mr. Sellon's patent. In the second place, the design shown in Figs. 1 and 2, and fully described by Mr. Kent, *would not work*, because any change in the density of the liquid, sufficient to cause the bulb to move *at all*, would send it right to the top or the bottom, whichever it happened to be, as there is nothing to stop it, unless the "*fine* wire of glass or of platinum" is supposed to displace so much of the solution that it would act like an ordinary hydrometer.

If the latter be the case, then the accuracy of the measurements indicated must depend upon the liquid being maintained always at an exact level in the cell, and I do not think there are many "gardeners" who could be depended upon to keep this level always constant.

Mr. Sellon's arrangement, shown in Figs. 3 and 4, also depends entirely upon the level of the liquid in the cell, and I feel sure the "gardener" would be too "heavy-handed" to adjust this always—even to one point of decimals—and a variation of one-tenth of an inch might cause much overcharging.

Mr. Parker's claim is for a simple form of hydrometer, which is not influenced by changes in the level of the liquid in the cell, and correctly indicates the density, so long as the bulb (which is of considerable size, in order to make the indications very accurate) is entirely below the surface of the solution. The weight is increased or diminished, as the arm carrying the balance weight forms a more or less acute angle with the perpendicular.

Mr. Sellon could obtain a similar, but I think less accurate effect—owing to friction, &c.—by using what is called a "fusee," instead of the pulley, in his "wheel-barometer" arrangement; but this would make it practically the same as what Mr. Parker claims.—Yours, &c., P. BEDFORD ELWELL.

8, Wilton-place, London, S.W., March 16.

(For continuation of CORRESPONDENCE *see page 371.)*

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THE WEST COAST OF AFRICA CABLE.

Considering the enormous capital invested and the commercial interests involved in Submarine Telegraph Cables belonging to this country they have, in our opinion, always been very inadequately represented at Westminster. The debate on the WEST AFRICAN CABLE CONTRACT last Friday week revealed the fact that what little representation they enjoyed in the old Parliament has been extinguished by the new electorate. Not property, not responsibility, not knowledge, but chiefly numbers now command a voice in the national deliberations; and unless the representatives of capital invested in submarine cables happen also to be men who can shout with the multitude, their interests may remain for the future undefended. This is greatly to be regretted, for the present composition of the House of Commons has already shown itself eager to assail any and every kind of proprietary right, and to regard no form of contract too sacred to be cancelled. We have seen in recent years how Cable Companies' affairs have suffered at the hands of responsible Ministers; how they will be handled by irresponsible legislators of the new order was sufficiently indicated the other evening.

The occasion was a very slight one indeed; but it was made the most of, and occupied the House for a couple of hours or more, furnishing material for many highly characteristic speeches. Ever since the troubles in South Africa the Government have recognised the necessity for a cable—or rather a series of cable sections—extending southwards along the West Coast of Africa, and placing our isolated colonies in that quarter of the world in direct communication with the home country The Brazilian Snbmarine Telegraph Company as far back as June, 1883, had offered to lay these cables, and some twelve months after tenders were invited by the Government in power, and after much negotiation, both by the Liberal Administration and their successors, the latter were able to make a bargain which everyone knows was a good one for the Government, whatever it may have been for the tendering company. A subsidy was in any case necessary for a term of years, as no cable could at present be worked there at a profit solely from commercial or private traffic. The amount of the subsidy was therefore alone in question; and the late Chancellor of the Exchequer managed to secure the cables for an annual grant vastly below the highest tender, and about £10,000 below that of the next lowest. This, too, with a perfectly sound and responsible company. The contract, which was concluded in January last, had to be submitted to Parliament for ratification; and it was this that gave Mr. HENNIKER HEATON, who represents the city of Canterbury, the opportunity he desired to make a gross personal attack upon the party or parties he was pleased to style "John Pender and Company." What he called his "mistrust" of this personage led him into making the wildest accusations of bad faith and dishonesty, without apparently the least ground for them, at all events in regard to this particular transaction, which Ministers and ex-Ministers alike described as perfectly straightforward and honest. Not often has the privilege of attacking in Parliament an absent man been so grossly abused. The member for Canterbury does not appear to know anything of cable construction, nor of England's needs in respect to national cable laying. He simply "suspected" and "mistrusted" the parties concerned, and declared he would prove them "dishonest" if an opportunity were afforded him in private. Such are the amenities of parliamentary life, which we have heard of in some of the Colonies, but which are a novel experience for us. We should like to know what the citizens of ancient Canterbury think of this new type of Conservatism.

The one tangible bit of ground for Mr. HEATON'S insinuations was the assertion that at the time the contract was signed with one company the cable had already been laid by another company. It was promptly explained that only a small section—a sixth of the whole—had been submerged; and that the transfer of the contract from the INDIA RUBBER COMPANY, who first undertook it at a high figure, was due to an agreement with the EASTERN TELEGRAPH COMPANY, who were prepared to carry it out at a much lower figure. But this was enough for the free lances of the smoke room, who forthwith, headed by Mr. LABOUCHERE, continued the fight on the highest moral grounds. It was shocking that all the facts, though utterly irrelevant, had not appeared on the face of the contract; it was especially monstrous that the EASTERN TELEGRAPH COMPANY, who possessed a lot of cables already, should own any more; and to clinch matters the payment of subsidies was radically bad in principle. The hon. member for Northampton confessedly knew less about the subject than the hon. member for Canterbury; but principles are quite above knowledge and far superior to good manners. Just as the village loafer in *Punch* salutes a stranger with "Let's heave a brick at him," so Mr. LABOUCHERE and his following make an ugly rush at this innocent contract, partly no doubt because they have a personal grudge against the contractor, but chiefly because they are grossly ignorant of the whole subject. That we are not exaggerating the facts, or needlessly protesting against the predatory spirit which actuated the debate, will be evident by a reference to the speech of Mr. ILLINGWORTH. This

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gentleman objected to the smallness of the sum—more than a fourth part of the whole—to be contributed by the colonies towards the annual subsidy. "It was," he said, "the large owners of land in those colonies that were chiefly interested, and it was to make them a great landed aristocracy that the late wars were waged; therefore, they ought to contribute a great deal more than £5,000 of the £19,000 required." The member for Bradford evidently does not know where the West African colonists are or what they are; but he thinks they are landowners, and that is enough for him.

Men who are betrayed into such follies as these by prejudice or spite are not likely to draw nice distinctions between one class of property and another. We do not suppose that Mr. ILLINGWORTH confessed himself wrong when presently informed that West African colonists for the most part do not own so much as three acres and a cow. They own something plainly, or they could not pay £5,000 a year; and if £5,000, why not eight or ten thousand? So with cable property generally. Evidently it is being regarded with jealous eyes by a certain section of politicians nowadays; and to protect itself against these, as well as against the more excusable assaults of foreign governments, who not unnaturally view our supremacy with irritation, some active steps ought to be taken to secure a better representation in the British House of Commons. Failing direct representation, surely there are shareholders in that assembly who would willingly become the mouthpiece of the companies on occasions like the one on which we have been commenting. If mutual jealousies prevent any joint action of the kind for their common safety, then the companies must expect to see themselves separately assailed and ruined in detail.

EFFICIENCY TESTS OF DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The difficulties in transmission-dynamometer tests, especially with engines which are not free from sudden jerks (in my case a gas engine), led me some time ago to derive the following method for determining the power transmitted to a dynamo:—

Instead of driving the dynamo to be tested directly by the engine, it is coupled to an electric motor which receives its current from a dynamo driven by the steam or gas engine. The efficiency of the electric motor being determined previously by means of a dynamometric brake (this being comparatively much more accurate and easy than a transmission dynamometer test), we have at once the power applied to the dynamo by measuring the current in the motor. Of course the greater part of the current in the motor can be supplied by the dynamo under test, as indicated by Dr. Hopkinson in your last issue. This more intricate arrangement would only be useful, however, in testing large dynamos, when there is no sufficient current for the motor otherwise.

If we would admit that magnetic and other friction is the same with or without current in armature (as is admitted in Hopkinson's test), then the commercial efficiency of a dynamo may be tested, as I indicated, *without any mechanical power measurement, only by measuring elec'ric quantities.*

Indeed, the loss in friction is determined by the difference in electric work supplied to the electric motor running at a given speed, when coupled to the dynamo (without current in armature) or disconnected from the same.

By inserting this letter in your next issue, you will oblige —Yours, &c., C. L. R. E. MENGES.

The Hague, Holland, 15th March, 1886.

MISTAKES IN ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your previous number there is an article by Mr. von Tunzelmann on "Mistakes in Electricity." As I do not agree with him about that which he calls mistakes, I should like to understand more clearly his meaning on one or two points which are of vital importance at the present stage of electrical science. I therefore make the following quotations from his article, page 347:—

"The student will have learned already, in the study of frictional electricity, that electricity can neither be generated nor destroyed. . . . We see that the motion of electricity is like that of a material fluid, an analogy which is often of great value in explaining electrical phenomena; but in making use of it the teacher should carefully guard against allowing the learner to suppose that in the electric current there really exists anything like an actual material fluid."

This extract makes it very plain that Mr. von Tunzelmann does not believe that electricity is any kind of matter whatever. But the following paragraph of his seems to convey the idea that electricity is a something, and not a mere nonentity. He states, "In the development of electricity, either by frictional apparatus or by a voltaic battery, the electromotive force is produced in the same way—viz., by the contact of two dissimilar substances; but in the first case, the requisite energy is obtained from mechanical sources." According to this paragraph, electricity is *a force*, and it is *energy*. Does Mr. von. Tunzelmann agree that this is his meaning?—Yours, &c., JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, 15th March, 1886.

THE ELECTRIC LIGHT AT THE PRINCE'S THEATRE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have great pleasure in handing you the following report of the second year's work of the installation at the Prince's Theatre, and trust you will find space for it in your journal at an early date.—Yours, &c., ERNEST L. BERRY.

This installation has now completed its second year of running, having run for two years without a breakdown or any mishap in the light. The plant consists of a 12 horse-power Clark gas engine, manufactured by Messrs. L. Sterne and Co., a Siemens S D_1 dynamo, and storage cells by the E. P. S. Co. There are 350 Swan lamps, 108 volts, 16 candle-power.

The engine has during the year run for 2,559 hours, and has not given the slightest trouble either in starting or when at work. It was overhauled in December last, and the water jacket cleared of its deposit of lime. The only renewal we have had for the engine has been a few piston rings. Besides doing its ordinary work of driving the dynamo it is used frequently for pumping water into the tanks to supply the hydraulic fire proof curtain and lift.

In regard to the E.P.S. cells, as a difficulty was experienced in the leaking of the teak boxes, it was decided while making a change to put in some of the new cells containing all the latest improvements, and supplied in glass boxes; and of these new cells, although put to very severe tests, not one has failed. We have repacked several of the teak boxes with new positive plates and lead connections, and these have answered admirably. We had up to 16th of January of this year one cell of the old type, which has been in constant work for two years, and has not on any occasion failed. It has not been repaired, or seen to in any way. It is eviden', therefore, that there is no reason why, when carefully made, the accumulators should not last throughout this length of time without being in any way renewed, and it is expected that this result will be attained with the later cells put down.

The dynamo has run very well. A new commutator was put on in December last; the old one during its run was turned up three times. There have been 10 pairs of brushes used during the 12 months. The lamps show a somewhat better average than last year, on account of our being able to get 30 of the broken-looped ones repaired. We have renewed during the year 78 lamps from the following causes—38 by carbons, 10 by accident, and 30 by loops breaking off.

The cause of so many loops being broken off is through using 18 lamps to light up a scene of "The Great Pink Pearl" for six months, the constant moving about breaking the loops, and occasionally one got broken by a fall. There are several

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lamps that were originally put up still burning, having run for 2,500 hours. Subjoined is an abbreviated account of the working expenses, and also the repairs and renewals for the year :—

WORKING EXPENSES.

Electrician and assistant	£239	5	6
Gas	188	4	0
Lamps	14	5	0
Oils for engine, shafting, dynamo, and pumps	10	0	0
Waste	1	12	6
10 pairs brushes	2	10	0
Lamp shades		15	0
Sundries, &c.	4	0	0
	£460	12	0

REPAIRS AND RENEWALS.

Dynamo	£12	9	0
Engine	7	0	0
Accumulators	187	9	6
Belts	11	5	4
	£218	3	10

Total for working	£460	12	0
Total for repairs, &c.	218	3	10
	£678	15	10
Previous year	452	10	0
Grand total for 2 years' working...	£1,131	5	10

Subjoined is Mr. Bruce's certificate as to the working of the installation :—

"I have great pleasure in again certifying to the successful working of the electric lighting at the Prince's Theatre. It has been in operation for more than two years, and during the whole of that period it has not failed on any one occasion. I am also greatly pleased at its adaptability for stage purposes; the lighting of the stage during one act of "The Great Pink Pearl" was most successful and original, and I hope before long to still further try its uses for stage effects.

"EDGAR BRUCE.

"The Prince's Theatre, March 11, 1886."

TELEPHONIC LITIGATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : Our attention has been called to a paragraph in your issue of the 26th ult. with regard to certain proceedings brought by the United Telephone Company against Mr. Fleming, of Liverpool, for alleged infringements of Bell's and Edison's telephone patents, in which you state that the company has withdrawn from the attack so far as Prof. Silvanus Thompson's instruments are concerned.

The action brought against Mr. Fleming had nothing whatever to do with Prof. Silvanus Thompson or with his telephone. The action was brought in respect of certain Bell telephones and carbon transmittters, which certainly were not supplied by the New Telephone Company. The United Telephone Company have withdrawn from nothing, and the action against Mr. Fleming will proceed upon the lines always intended.—Yours, &c.,

WATERHOUSE, WINTERBOTHAM, AND HARRISON.

1, New-court, Carey-street, Lincoln's Inn, W.C.
March 17, 1886.

HOLBORN VIADUCT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : May I ask Mr. Hartnell if the Edison lamps now supplied to consumers on the Holborn Viaduct are a fair sample of those he speaks of having burned so long a time ? If such is a fact I am not surprised at their long life. My attention was drawn towards a window burning these lamps, the weakness of which caused me to "inquire within." I found the lamps inside no better than those in the window. The consumer was not at all satisfied with the light, and wished it out. He had been a strong advocate of electric light, and I believe was a large holder of stock in some company, but whose name he did not mention. He asked me the cause of the lamps burning so poorly. Being compelled to dig out a living by this business, which, through these very defects in other people's instruments, only enables me to live in a garret until the public are enlightened as to the causes of such imperfection, I went at once to inform the managing engineer to put on a little more steam, as his customers were becoming disgusted with the light, when, for my interest and that of the profession, they should be encouraging. I was refused admittance (perhaps from fear of my carrying off one of the company's dynamos). I feel safe in saying that until the electrical engineer tries to help the public to see it by explaining clearly the causes that can produce such effects, domestic lighting will progress with but little speed.—Yours, &c., BONEO.

YET ANOTHER DISCOVERY!

TO THE EDITOR OF THE ELECTRICIAN.

SIR : It appears to me that the votaries of electrical science are happily chosen to render the duties of the medical man less and less arduous ; and, by your leave, I shall endeavour to explain an idea—I will not say a grand idea, because *real* genius is modest—which, if acted upon, cannot fail to be of use to that worthy soother of pain.

We have the telegraph to communicate with our correspondents through, and we have the telephone by which we can give our wives due notice that Jones is coming to dine with us. Why, then—coming to another very important requirement—why should not the medical man be able to ascertain the temperature of his fever-stricken patient, as well as give his instructions as to treatment, *by wire* from his very consulting room ? This is a question which put itself very forcibly to me the other day while I was stretched out in my long chair pensively smoking a cigar. The solution came as an inspiration, and I felt highly elated. (I wonder if Sir William felt like that when the "mirror" flashed across his great mind ?) For the benefit of mankind and the doctors I give that solution.

A well-insulated wire must be laid from the consulting room to the patient's house. At one end a suitable metallic handle soldered to the line wire must be arranged so that the patient can place it under his arm, as he would a thermometer, when required. At the other end a very sensitive galvanometer, the line wire joined to one terminal and a wire leading to earth joined to the other terminal. I may here remark that this idea is especially applicable to fever-laden parts of the globe, where fever is the rule and not the exception. We will say, for example, East or West Africa. Earthing *there* by means of the gas pipe is not always possible, so the medico's best plan to make sure of good earth will be to solder the lead to a copper plate and bury that plate in the nearest swamp, for it is pretty certain that there is a swamp not far off. For the sake of economy the same wire can, by switching, be used for telephonic conversations and for the temperature-reading idea ; so we will suppose the arrangement complete.

Medico rings the bell, and is answered by the patient's nurse —usually a nigger in Africa.

Medico : "Where is your master ?"

Sambo : "In bed, saar."

Medico : "Switch over and put the handle under his arm for three minutes."

Sambo : "All right, saar."

It is done, and the medical man observes a very *slight* deflection of his galvanometer needle.

"Hum !" mutters he, "fever still high, 104°."

Three minutes elapse. He rings. Sambo answers.

Medico : "Tell your master to take another Dover's powder, and pile on some more blankets. I shall ring again in two hours."

Sambo : "Right, saar."

Two hours, during which time the medical man has been comfortably seated in his arm-chair listening to the pour-

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ing rain outside, and thanking "his stars" that he has *now* no need to expose himself to it; the two hours elapse. Preliminaries are gone through as before, and when the handle is placed under the patient's arm the deflection is considerably *larger*. "Bravo!" exclaims Medico, "temperature gone down to 100 deg.!"

He switches over and rings.

Sambo: "Yes, saar."

Medico: "Your master is perspiring, isn't he?"

Sambo: "Yes, saar."

Medico: "Then tell him to take fifteen grains of quinine at once."

Sambo: "Fifteen grains; all right saar."

Medico: "I will ring again in two hours."

Need I explain that when the body is hot and dry with fever the galvanometer needle will be deflected only slightly, and that when it is damp with the thrice welcome beads of perspiration, the needle will be deflected considerably more? And cannot a doctor have his galvanometer scale so arranged that it will be easy for him to arrive at the temperature of the distant patient's body by those deflections?

Sensible persons suffering from fever invariably remain in bed until it has left them. Therefore, the medico can, after a little experience, make out a simple table of "In Bed Deflections," thus:—

Hot, dry Skin.			Cool, moist Skin.		
Deflection.		Temp.	Deflection.		Temp.
17	=	103°	26	=	99·5°
and so on.			and so on.		

But there are some people who will sit muffled up in an arm-chair with their slippered feet upon the carpet. In this case a table of "Feet on the Carpet Deflections" will be necessary.

Example:—

Dry.	Moist.
29 = 103°	37 = 99·5°
and so on.	and so on.

And if the patient has no carpet upon the floor, another table, headed "Feet on the Bare Floor Deflections," is called for.

Example:—

Dry.	Moist.
41 = 103°	52 = 99·5°
and so on.	and so on.

The medical man will see that the less insulating substance there is between his patient and the foundation of the house the greater will be the deflections, so he must always ask Sambo where "massa" is before taking the temperature. He will then know exactly which series of deflections to hit upon.

Here, then, is another drop of nectar for the doctor's fast-filling cup! If he avails himself of it, it will bring him personal comforts long, long given up as unattainable; it will serve as food for reflection; it will bring wondering myriads to his door, and soon he will be looked upon as an exalted performer of miracles! And, furthermore, Sir, the modest aim of one who prefers the doctor's room to his company will have secured its moral bull's-eye!—Yours, &c.

Zanzibar, February, 1886. NORMAL TEMP.

[We are always, or nearly always, glad to hear from our friends abroad; but when it comes to printing their letters we do wish they would call to mind that proverb of their native land which says, Brevity is the soul of wit.—ED. *Electrician.*]

RELATIONS OF SURFACE-RESISTANCE AT ELECTRODES TO VARIOUS ELECRICAL PHENOMENA.*

BY G. GORE, LL.D., F.R.S.

In some experiments described in a paper on "Evidence Respecting the Reality of 'Transfer-resistance' in Electrolytic Cells," read before the Birmingham Philosophical Society, January 21, 1886, I found that when a current of voltaic electricity was passed from dilute nitric or sulphuric acid, or strong nitric acid, into the surface of a thin platinum bottle used as a cathode, the temperature of the bottle suddenly rose, notwithstanding that certain amounts of heat must have been absorbed by the copious liberation of hydrogen which occurred, and by that substance assuming the gaseous state, each at the surface of the bottle; and I further found that this rise of temperature was not due to heat produced by ordinary conduction-resistance of the bottle or of the liquid, nor to resistance of any kind at the anode, and that it was due to some influence other than that of chemical change, at the surfaces of mutual contact of the liquid and bottle; and further, that it varied in quantity directly as the amount of "resistance" to the passage of the current into the surface of the bottle. I also found similar thermal effects of "resistance" at the surface of the bottle, when the latter was used as an anode.

In a previous investigation on "transfer-resistance" (*Proc.* Royal Soc., Vol. 38, p. 209), I also found "that a species of electric resistance distinct from that of polarisation and of ordinary conduction-resistance, varying greatly in amount in different cases, exists at the surfaces of mutual contact of metals and liquids in electrolytic and voltaic cells. That this resistance varies largely in amount with different metals in the same solution, and with the same metal in different solutions," "and is usually small with easily corrodible metals which form readily soluble salts, and large with those which are not corroded," and "that the same voltaic current was resisted in different degrees by every different metal when employed as an anode, and when used as a cathode," "and that the resistance at the anode was usually smaller than that at the cathode," and "that by rise of temperature, 'transfer-resistance' was usually considerably reduced." This "transfer-resistance" differs essentially from electric potential, because it is incapable of producing a current.

The present experiments were made for the purpose of examining some relations of this "surface-resistance" to various electrical phenomena. I call it "surface-resistance" in the present case, because in consequence of omission of stirring, it includes other forms of resistance besides that of "transfer" at the surfaces of mutual contact of the metals and liquids employed.

First.—In cases of thermo-electric currents produced by heating the junction of a metal and electrolyte. We know that when heat is applied to one of the two ends of a piece of non-corrodible metal in contact with opposite parts of an electrolyte, an electric current is usually produced, and we infer from the principle of conservation of energy that when such a current occurs, heat is absorbed and disappears at or near the heated junction, and is converted into and produces the current.

In order to determine whether the relative amounts of "surface-resistance" at the junctions of such a thermo-couple vary with temperature, and also whether the direction of current produced by such a couple is influenced by the relative total amounts of such "resistance" in the two directions in the circuit, I made the following experiments:—

The liquids employed were dilute sulphuric and nitric acids, each being composed of one volume of strong acid and ten volumes of water; and the electrodes were two perfectly similar sheets of platinum, each having a total immersed area of surface of about 24·0 sq. cm.

The thermo-electric apparatus consisted of a vertical glass tube, open at its upper end, 19·0 cm. high, and 3·0 cm. internal diameter (see sketch on next page). One of the platinum plates was suspended vertically in the upper end of the tube by means of a platinum wire; and the other, welded to a stout platinum wire, was supported vertically in the lower end by passing a wire through a cork fixed in a hole in a vulcanised india rubber bung which closed the end of the tube. The two plates were 9·0 cm. apart. The glass tube was nearly filled with the acid liquid; its upper end was surrounded by a water bath, the water in which was heated by applying a flame to a projecting arm of the bath. The bulb of a thermometer was immersed in the acid liquid near the upper plate; and the wires from the plates were attached to a dead-beat D'Arsonval

* Read before the Birmingham Philosophical Society, Jan. 21. [In our issue of Feb. 19 a paper on "Evidence respecting the Reality of Transfer-Resistance in Electrolytic Cells" was wrongly stated to have been read before the Royal Society; it should have been the Birmingham Society.]

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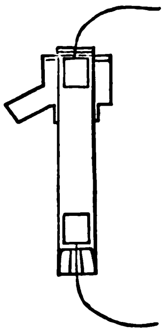
galvanometer. The liquids were not stirred during the experiments.

With the lower plate at 14° C., and the upper one at 95° C., in the dilute nitric acid, a thermo-electric current of about ·00004 ampere was produced. At the same temperature, in the dilute sulphuric acid, the strength of current produced was about 00001 ampere. The current flowed from the cold plate through the liquid to the hot one in each case. As platinum is a thermo electric positive substance, though in a feeble degree, in metallic couples, these results indicate that both these liquids were thermo-electro-positive, and much more strongly so than platinum.



The electromotive forces of these couples during a state of balanced current were measured by means of a modified form of Poggendorff's method, and the values found were as follows: —With the plates at 14° and 95° C, in the dilute nitric acid, ·418 volt.; in the dilute sulphuric acid, ·282 volt.; and in a mixture of one volume of hydrochloric acid and ten of water, ·208 volt.

The amounts of "surface-resistance" were also measured by using a rheostat as a slide-wire bridge; the same electrodes, with the same amounts of immersed surface, being employed as were used in the thermo electric experiments. The electrodes faced each other at about 5·0 cm. apart in the respective liquids in a glass cup, the one which was positive in the thermo-couple being used as the anode; and the strengths of current employed were the same as the thermo-electric ones, because I have found that an alteration of strength of current affects the amount of "transfer-resistance." One terminal of a Thomson's reflecting galvanometer of 3,045 ohms resistance, was connected with the slider, and the other connected, first to the anode (or cathode), and then to a vertical platinum wire (or idle electrode) immersed in the liquid close to the anode (or cathode) but not touching it; a balance being obtained in each case by moving the slider.

In the dilute nitric acid, with a current of ·00004 ampere, the amounts of "surface-resistance" were :—

	At 14° C.	At 95° C.
At the anode.........	49266· ohms	531· ohms
At the cathode......	29784· „	494· „

By a rise of temperature, therefore, of one of the pieces of platinum of the thermo-electric couple 81 centigrade degrees, the amount of "surface-resistance" of that piece was reduced, as a cathode or in the direction of the thermo-electric current 98·34 per cent., and in the opposite direction, or as an anode, 98·92 per cent.; and the total "surface-resistance" in the circuit was also reduced 37·05 per cent. in the direction of that current, and 61·65 per cent. in the opposite one.

The results also show that the cold platinum offered 39·55 per cent., and the hot platinum of 6·97 per cent., less amount of "surface-resistance" as a cathode than as an anode; also that the total amount of such "resistance" in the two directions in the circuit, when one of the junctions was heated to 94°C., was 64·14 per cent. greater in the direction of the thermo-electric current produced than in the opposite one.

In the dilute sulphuric acid, with a current of ·00001 ampere, the amounts of "surface resistance" were :—

	At 14° C.	At 95° C.
At the anode	63500· ohms	3848· ohms
At the cathode ...	18350·	2152· „

By a rise of temperature, therefore, of one of the pieces of platinum of the thermo-electric couple 81° C., the amount of "surface-resistance" of that piece was reduced in the direction of the thermo-electric current or as a cathode 88·27 per cent., and in the opposite direction, or as an anode, 93·94 per cent.; and the total "surface-resistance" in the circuit was also reduced 19·79 per cent. in the direction of that current, and 72·88 per cent. in the opposite one.

The results also show that the cold platinum had 71·10 per cent. and the hot platinum 44·08 per cent. less amount of "surface-resistance" as a cathode than as an anode; also that the total amount of such "resistance" in the two directions in the circuit, when one of the junctions was heated to 94° C., was 195·75 per cent. greater in the direction of the thermo-electric current than in the opposite one.

The results obtained with these two liquids show that the amount of "surface-resistance" at each junction of such thermo-electric couples varies very greatly with temperature; and that the amount of such "resistance" to the passage of a current in either direction was more largely decreased by rise of temperature with the dilute nitric than with the sulphuric acid. I had previously found with thermo-electric couples composed of metals and electrolytes, "that by rise of temperature 'transfer-resistance' was usually and considerably reduced." (*Proc.* Roy. Soc., 1885, No. 236, p. 210.)

The direction of thermo-electric current produced in each of these two cases was the same as that indicated by the relative amounts of "surface-resistance" in opposite directions at the heated junction, but the reverse of that indicated by the relative total amounts of such "resistance" in opposite directions in the entire circuit.

As in each of the two couples, the total amount of "surface-resistance" in the circuit when one of the junctions was heated, was very much greater in the direction of the thermo-electric current produced than in the opposite one, I conclude that the direction of that current was not chiefly determined by the alteration of such "resistance" by rise of temperature. The thermo-electric action, and the "surface-resistance" therefore, appear to be largely distinct phenomena; and as both liquid and metal in those couples were thermo-electro-positive substances, the direction of the current was probably caused chiefly by the thermo-electric-positive potential of the liquid, increasing more rapidly than that of the metal by rise of temperature. We may also infer that the strength of the thermo-electric current in those couples was very largely increased by the great diminution of "surface-resistance."

In a paper on "Some Relations of Heat to Voltaic and Thermo-electric Action of Metals in Electrolytes" (*Proc.* Royal Soc., 1884, No. 233, pp. 251-290), I have shown by numerous experiments that "when metals in electrolytes were heated they were more frequently rendered electro-positive than negative, in the proportion of about 2·8 to 1·0; the proportion in strong solutions was about 3·27 to 1."

Second.—With regard to voltaic couples. As heat affects largely the amount of "surface-resistance," and the strength of current, in a thermo electric couple composed of a metal and an electrolyte, we may infer that it would also, chiefly by altering that "resistance," affect the strength of current in a voltaic cell.

In order to experimentally examine this, the lower platinum plate in the thermo-electric apparatus already described was replaced by a rod of amalgamated zinc 8·0 mm. long and 2·0 mm. thick, the upper platinum plate being retained in its place. The tube was then filled with the cold mixture of one volume of sulphuric acid and 10 of water.

With the entire apparatus and liquid at 14° C., the electromotive force (determined by the above-named method) was ·704 volt., and the strength of current without additional resistance in the circuit was ·022 ampere.

With the platinum plate and upper portion only of the liquid at 95° C., and the zinc electrode and liquid around it at 14° C., the electromotive force was ·763 volt., and the strength of current 0·705 ampere.

These results show that the electromotive force was increased about 8·38 per cent., and the strength of current 220 per cent., or to 3·2 times its original amount, by raising the temperature of

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the platinum negative 81 C. degrees. This increase of strength of current was about 24 per cent. greater than when the lower plate was composed of platinum. This great increase of current was, I consider, largely due to decrease of "surface-resistance" at the negative plate, and in some measure also to the increase of electromotive force attending increased thermo-electro-positive potential of the liquid; also to several other manifest but minor circumstances, such as diminished conduction-resistance of the liquid, &c.

Third.—With regard to the thermo-electric phenomena of metals. Some experiments were made to try and detect any special degree of resistance at the junctions of ordinary metallic thermo-electric couples in the following manner.

The first couple consisted of a smooth horizontal bar of bismuth, and one of antimony, soldered end to end; each bar being 2·0 cm. long, ·7 cm. wide, and ·5 cm. thick. Whilst a current of ·2 ampere was being passed from one end of the bar to the other, the ends of two thin copper wires, about 1·0 cm. apart, forming the terminals of a Thomson reflecting galvanometer of 3,040 ohms resistance, were slid very slowly at right angles to and in a horizontal direction, from one end to the other, to and fro, along the upper surface of the couple; the direction of voltaic current being occasionally reversed. Under these conditions, a small portion of the current passed through the galvanometer. There was no sudden change in the deflection of the needles at any time when the wires crossed the junction of the two bars. A similar negative result occurred when a thermo-couple formed of iron and German silver wires 1·5 mm. diameter was employed; and also when a pair composed of platinum wire and mercury was used.

Had there existed a difference of resistance equal to ·001 ohm at the junction in either case, it would probably have been detected. I conclude, therefore, that if "surface-resistance" of any kind exists at the junctions of metallic thermo-electric couples, it must be exceedingly small in amount, and that it does not sensibly affect the direction or strength of the currents produced by them.

Some attempts were made to ascertain whether the amount of "transfer-resistance" at an electrode formed of a loop of platinum wire was affected by passing a separate current of electricity through it simply as a conductor, but the results were not satisfactory.

Various of the results of experiments described in this paper agree with the conclusion that differences of "transfer-resistance" are incapable of producing a current, and are essentially unlike differences of electric potential; also, that heat decreases "transfer-resistance" whilst increasing contact-potential in metal-electrolyte thermo-electric couples.

DYNAMO TESTS.

(Concluded from page 357.)

The tables show a gradual decrease in the efficiencies, the difference between the first and last values being about one per cent.

The cause seems to be the different amounts of lead given the brushes. If we compare the first with the third test, it will be seen that, with about the same current in the field and a greater number of revolutions of the armature the E.M.F. of the latter test is about five volts less than that of the former. In the last test, with the speed still further increased and with the field current about constant, the E.M.F. is slightly less than in the third measurement.

The partial load tests were made after the constant had become steady. After the three-quarter load test, a measurement was made on full load. As it was not made under the provisions of the code, it is marked "unofficial" in the table. The half load test was repeated to check the former measurement. The difference of ·3 per cent. in the total efficiencies is probably accounted for by the slight increase of armature friction caused by running on the three-quarter load. The greatest value of the commercial efficiency is on three-quarter load, the slightly less value of the total efficiency, as compared with the full load, being more than counterbalanced by the smaller loss in the armature and field

Weston No. 6 M. Dynamo.

Diameter of armature	$8\frac{1}{32}$in.
Weight of machine	2,000
Number of commutator bars	72
Total number of turns	144
Turns per commutator segment	2
Average length of a turn	6ft. 5in.
Must brushes be adjusted?	slightly.
Diameter of bearing, pulley end	$1\frac{5}{8}$in.
Diameter of bearing, commutator end	$1\frac{3}{8}$in.
Length of bearing, pulley end	$6\frac{3}{4}$in.
Length of bearing, commutator end	5in.
Number of turns per minute	1,150
Volts for best work	120
Amperes for best work	80

Table IV., on p. 376, gives the results of the measurements.

The full load measurements probably agree as closely as the conditions of the tests. There was a good deal of sparking at the brushes, and the machine seemed overloaded.

For the partial loads, the total efficiency increased up to the three-quarter load, and there was little sparking at the commutator. On the unofficial full load test, the sparking was quite violent, and the efficiency fell about two per cent. from the three-quarter load. Comparing the unofficial full load with the tests of the day before, and applying the difference of armature friction to the former, it will be seen that the total efficiency for the unofficial test is less, the load being greater and the efficiency at this load decreasing rapidly as the load increases.

Edison No. 4 Dynamo.

Diameter of armature, $6\frac{1}{4}$in. inside, $7\frac{1}{16}$in. outside.	
Weight of machine	1,470
Number of communicator bars	50
Turns in one coil	2
Length of useful wire in a coil	48in.
Must brushes be adjusted?	Yes.
Diameter of bearing	$1\frac{1}{4}$in.
Length of bearing	$6\frac{1}{4}$in.
Turns per minute	1,600
Volts for best work	125
Amperes for best work	80

Table V., on p. 376, gives the results of the measurements.

This machine was not coupled directly to the dynamometer, the high speed required being deemed unsafe. It was run by a belt from a pulley on the transmission shaft of the dynamometer. In allowing for the loss due to the belt, it was assumed that for the full load the friction of the armature was the same as that of the No. 5 dynamo.

The full load tests agree very closely, the total efficiencies increasing slightly with the horse-power, the commercial efficiences differing very little.

The measurements on the partial loads are perhaps a little low, as it is probable that sufficient allowance was not made for the belt. The temperature was much lower than for the full load tests and the belt was probably stiffer.

Edison No. 20 Dynamo.

Diameter of armature	$9\frac{1}{16}$ inside, $10\frac{5}{8}$ outside.
Weight of machine	8,331 pounds.
Number of commutator bars	44
Turns of wire in a coil	1
Length of useful wire in a coil	59in.
Must brushes be adjusted?	Yes.
Diameter of bearing	$2\frac{5}{8}$in.
Length of bearing	$10\frac{7}{8}$in.
Number of turns per minute	1,000
Volts for best work	125
Amperes for best work	400

Table VI., on p. 376, gives the results of the measurements.

The full load tests are marked unofficial, because the preliminary run of ten hours was not on full load. The machine was started at the usual time, midnight, with about the right load, but in a few hours the power fell to about fifty horse-power, and remained about the same until noon of June 19th,

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TABLE IV.—(*Weston No. 6 M. Dynamo.*)

Date	June 13th.				June 14th.			
Time	11·52	1·50	2·25	3·55	12·15	2·20	4·00	4·39
Load	Full.	Full.	Full.	Full.	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	Full.*
E. M. F. at terminals	117·4	115·4	118·89	119·86	119·70	122·41	119·19	124·41
Total E. M. F.	124·59	122·37	126·26	127·17	121·70	125·23	125·12	131·76
Current in external circuit	71·85	70·62	72·45	71·56	20·535	39·878	60·705	75·65
Current in field	1·277	1·254	1·280	1·286	1·236	1·214	1·246	1·318
External resistance	1·634$_d$	1·634$_d$	1·641$_d$	1·675	5·827	3·070$_c$	1·963$_d$	1·645$_d$
Armature resistance	·0983	·0969	·0999	·1003	·0921	·0940	·0957	·0956
Field, with box	91·93	92·00	92·91	93·20	96·79	100·9	95·69	94·42
Field, alone	...	...	...	...	...	...	...	...
Power applied	12·89	12·48	13·15	13·17	3·979	7·341	10·774	14·390
Total electrical energy	12·23	11·80	12·49	12·429	3·554	6·962	10·40	13·606
External electrical energy	11·32	10·93	11·56	11·508	3·297	6·55	9·708	12·627
Energy in armature	·705	·672	·729	·714	·0585	·213	·493	·759
Energy in field	·201	·194	·204	·207	·19.5	·1993	·1992	·2199
Total efficiency	94·82	94·53	94·98	94·37	89·33	94·84	96·53	94·55
Commercial efficiency	87·79	87·59	87·88	87·38	82·87	89·23	90·10	87·75
Economic coefficient	92·58	92·66	92·53	92·59	92·77	94·08	93·34	92·80
% power in armature	5·48	5·38	5·55	5·43	1·47	2·90	4·58	5·28
% power in field	1·56	1·56	1·56	1·57	4·99	2·71	1·85	1·53
No. revolutions	1099·6	1101·9	1117·8	1114·9	1110·7	1109·5	1113·7	1154·2
Friction of armature	·298	·298	·298	·298	·1672	·1672	·1672	·1672
Temperature of air	30·4° C.	31 ° C.	30·5° C.	30·5° C.	34·° C	33·5° C.	...	...
Temperature of pole-piece	37·7° C.	41·2° C.	41·6° C.	41·5° C.	36·7° C.	39·5° C.	...	...

TABLE V.—(*Edison No. 4 Dynamo.*)

Date	June 16th.				June 17th.			
Time	2·16	3·30	4·25	5·20	11·00	12·15	2·15	2·40
Load	Full.	Full.	Full.	Full.	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	Full.*
E. M. F. at terminals	120·05	124·95	125·20	126·75	128·66	128·77	128·39	131·17
Total E. M. F.	124·64	129·61	129·97	131·91	130·00	131·09	132·22	137·08
Current in external circuit	72·919	75·93	76·12	82·10	22·36	39·55	63·58	90·68
Current in field	1·915	2·244	2·211	2·321	1·940	2·082	2·222	2·647
External resistance	1·646$_d$	1·646$_d$	1·647	1·543$_e$	5·755$_e$	3·256$_d$	2·019	1·446$_e$
Armature resistance	·0614	·0596	·0610	·0611	·0550	·0556	·0582	·0634
Field, with box	62·68	55·68	56·63	54·58	66·33	61·85	57·78	49·55
Field, alone	44·17	44·46	44·69	44·59	40·42	41·21	42·29	...
Power applied	13·284	14·383	14·442	15·786	5·050	8·168	12·517	18·053
Total electrical energy	12·51	13·60	13·64	14·93	4·237	7·322	11·67	17·17
External electrical energy	11·746	12·73	12·77	13·95	3·859	6·833	10·95	15·96
Energy in armature	·461	·488	·501	·584	·0436	·129	·338	·741
Energy in field	·309	·376	·371	·394	·335	·360	·382	·466
Total efficiency	94·21	94·53	94·47	94·58	83·89	89·65	93·26	95·09
Commercial efficiency	88·42	88·52	88·43	88·38	76·40	83·65	87·50	88·40
Economic coefficient	93·85	93·64	93·61	93·45	91·07	93·32	93·82	92·97
% of power in armature	3·47	3·40	3·47	3·70	·86	1·59	2·70	4·10
% of power in field	2·32	2·61	2·57	2·49	6·63	4·41	3·06	2·58
No. revolutions	...	...	...	...	...	...	...	...
Friction of armature	·14	·14	·14	·14	·16	·16	·16	·16
Temperature of air	35·5° C.	36·5° C.	36·2° C.	36 ° C.	21·° C.	23 ° C.	25·° C.	24·8° C.
Temperature of pole-end	45·8° C.	45·5° C.	46·1° C.	45·5° C.	27·2° C.	29·5° C.	33·3° C.	34·6° C.

TABLE VI.—(*Edison No. 20 Dynamo.*)

Date	June 18th.			June 19th.			
Time	1·00	2·25	3·50	9·45	1·30	2·45	4·00
Load	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	Full.*	Full.*	Full.*	
E.M.F. at terminals	126·16	122·0	123·99	105·95	125·04	125·4	
Total E.M.F.	127·46	124·10	127·55	110·00	129·60	129·85	
Current in external circuit	100·22	192·46	291·16	330·88	387·28	379·00	
Current in field	4·942	4·915	5·124	4·397	5·136	5·124	Armature insulation gave way.
External resistance	1·258$_d$	·6338$_d$	·4161$_d$	3·202$_d$	·3229$_d$	·3308$_e$	
Armature resistance	·0124	·0106	·0120	·0121	·0116	·0119	
Field, with box	25·53	24·82	24·20	24·10	24·35	24·47	
Field, alone	...	...	...	...	...	...	
Power applied	20·254	35·43	53·11	51·06	70·72	69·39	
Total electrical energy	17·985	32·86	50·71	49·48	68·25	66·97	
External electrical energy	16·965	31·50	48·44	47·04	64·99	63·76	
Energy in armature	·1838	·556	1·416	1·82	2·40	2·35	
Energy in field	·837	·809	·852	·625	·862	·862	
Total efficiency	88·80	92·77	95·46	96·91	96·51	96·52	
Commercial efficiency	83·76	88·93	91·19	92·11	91·90	91·89	
Economic coefficient	94·33	95·86	95·53	95·06	95·22	95·21	
% power in armature	·91	1·57	2·66	3·57	3·39	3·38	
% power in field	4·13	2·27	1·61	1·23	1·22	1·25	
No. revolutions	1008·9	1023·9	1008·8	1022·3	1092·41	1090·2	
Friction of armature	..	...	...	·393	·393	·393	
Temperature of air	28·5° C.	28·5° C.	28·5° C.	31·5° C.	33·° C.	33·5° C.	
Temperature of pole-piece	35·0° C.	37·8° C.	38·3° C.	44·5° C.	45·° C.	47·8° C.	

* Unofficial.

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TABLE VII.—(*Weston No. 6 W. I. Dynamo, 130 Volts.*)

Date	June 22nd.		June 23rd.				
Time	...	2·00	12·40	2·20	3·35	4·35	5·35
Load	¼	½	Full.*	Full.	Full.	Full.	¾
E.M.F. at terminals	125·06	124·29	128·45	129·00	124·8	131·8	133·7
Total E.M.F.	126·17	126·34	133·12	133·87	129·89	136·22	137·19
Current in external circuit.	25·51	46·19	108·94	109·29	114·2	98·33	81·99
Current in field	2·051	2·144	2·239	2·213	2·171	2·272	2·242
External resistance	$4·901_d$	$2·691_d$	$1·180_d$	$1·180_d$	$1·093_e$	$1·340_e$	1·630
Armature resistance	·0404	·0424	·0420	·0437	·0438	·0439	·0441
Field, with box	60·96	57·96	57·37	58·28	57·51	58·01	59·62
Field, alone	...	...	...	...	...	...	...
Power applied	5·092	8·820	20·98	20·71	21·01	19·28	16·48
Total electrical energy	4·666	8·193	19·86	20·03	20·29	18·39	15·50
External electrical energy	4·281	7·703	18·78	18·92	19·13	17·39	14·70
Energy in armature	·0412	·1329	·697	·729	·795	·596	·394
Energy in field	·344	·358	·386	·383	·364	·402	·402
Total efficiency	91·64	92·89	94·68	96·69	96·53	95·39	94·06
Commercial efficiency	84·07	87·32	89·51	91·32	91·02	90·21	89·22
Economic coefficient	91·74	94·01	94·54	94·45	94·29	94·57	94·86
% power in armature	·81	1·51	3·32	3·52	3·78	3·09	2·39
% power in field	6·76	4·05	1·84	1·85	1·73	2·09	2·44
Number of revolutions	1167·2	1168·3	1258·5	1267·6	1250·6	1257·6	1252·3
Friction of armature	...	...	...	·13	·13	·13	·13
Temperature of air	31·° C.	31·° C.	27·5° C.	27·5° C.	25·° C.	25·7° C.	...
Temperature of pole-piece	35·° C.	37·° C.	35·5° C.	35·5° C.	36·7° C.	36·7° C.	..

* Rejected.

TABLE VIII.—(*Table of Efficiencies.*)

	Volts.	Amperes.	Weight.	Total Efficiencies.				Commercial Efficiencies.			
				Full Load.‡	¾ Load.	½ Load.	¼ Load.	Full Load.‡	¾ Load.	½ Load.	¼ Load.
Edison No. 4	125	80	1,470lbs.	94·45	93·26	89·65	83·89	88·44	87·40	83·65	76·40
Edison No. 5*	125	100	2,475lbs.	96·01	...	...	...	89·19	...	...	...
Edison No. 10	125	200	4,710lbs.	94·68	92·44	90·55	83·32	89·61	88·23	86·12	77·53
Edison No 20*	125	400	8,331lbs.	96·65†	95·46	92·77	88·80	91·96†	91·19	88·93	83·76
Weston 6 M.	120	80	2,000lbs.	94·67	96·53	94·84	89·33	87·66	90·10	89·23	82·87
Weston 7 M.	160	125	3,300lbs.	96·56	96·38	94·84	90·08	89·37	90·49	89·57	84·37
Weston 6 W. I.	130	100	2,100lbs.	96·20	94·06	92·89	91·64	90·85	89·22	87·32	84·07

* Armature insulation gave way. † Unofficial. ‡ Average of full load measurements.

when by increasing the number of revolutions, the proper load was nearly attained. The tests were to have been repeated the next day, but unfortunately the insulation of the armature gave way, making this impossible.

The tests seem to agree quite well. It is hard to compare the first full load measurement with the others, as the conditions were different. The two full load measurements made under about the same conditions agree almost exactly.

WESTON NO. 6 W. I. DYNAMO.

Diameter of armature	8¼in.
Weight of machine	2,100 pounds.
Number of commutator bars	56
Total number of turns in armature coils..	112
Turns per commutator segment	2
Average length	6ft. 3½in.
Must brushes be adjusted ?	Slightly.
Diameter of bearing, pulley end	1⅝in.
Diameter of bearing, commutator end ...	1⅜in.
Length of bearing, pulley end	6¾in.
Length of bearing, commutator end	5in.
Turns per minute	1,200
Volts for best work	130
Amperes for best work	100

Table VII. above gives the results of the measurements.

The values of the total efficiency for the different measurements of this machine differ widely. The first test gives a much smaller value than the rest, and is rejected, because, whether the difference is caused by errors in the measurements, or in the adjustment of the machine, the test evidently does not represent the normal efficiency of the dynamo.

Table VIII. above gives a summary of the tests.

In the table, the full load efficiencies of the Edison No. 20 dynamo are marked "unofficial," because the preliminary run was not in conformity with the code, not because there is any reason to mistrust the results.

Of the fifty-four measurements made, four were for obvious reasons deemed unworthy of calculation. These were two tests of the Edison No. 5 dynamo, and a couple of partial load tests of the Weston No. 7 M machine, made while the constant of the potential galvanometer was unsteady. Of the remaining fifty tests, but one is rejected—a full load measurement of the Weston 6 W. I. dynamo.

Considering the care taken in standardizing all of the instruments used in the measurements, and the very close agreement of tests made on the same dynamo, it seems probable that the results given in the above table represent very nearly the efficiencies of the machines under the conditions of the tests.

The dynamos were favoured by being coupled directly to the dynamometer, and it will be seen on looking at the tables that the loss by friction was slight.

In the measurements, the ohm was taken at 106 centimetres of mercury, so in order to reduce the values to absolute measure the potentials, and therefore the efficiencies, should be reduced by about one-fourth per cent.

DIRECT SPANISH TELEGRAPH COMPANY.—The report of this company shows that after providing for the repairs of the new Bilbao cable (£2,959), and for fixed charges, there remains a credit to profit and loss of £1,449. Of this sum it is proposed to add £1,400 to reserve, leaving £49 to be carried forward.

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EFFECTS OF STRESS AND MAGNETISATION ON THE THERMO-ELECTRIC QUALITY OF IRON.*

BY PROF. J. A. EWING, B.Sc., F.R.S.E., University College, Dundee.

This paper comprises a revised version of one submitted to the Royal Society in 1881, under the title "Effects of Stress on the Thermo-electric Quality of Metals, Part I.,"† along with much new matter. It deals principally with the cyclic changes of thermo-electric quality which an iron wire undergoes when exposed to cyclic variations of stress (described in the abstract of the former paper), and with the relations of these changes of thermo-electric quality to the changes of magnetism which also occur as an effect of stress. Stress was applied by exposing the wire to longitudinal pull by means of loads.

The changes both of thermo-electric quality and of magnetism exhibit that tendency to lag behind the changes of stress to which in a previous paper ‡ the author gave the name *hysteresis*, and the effects are sufficiently similar in regard to the two qualities to suggest that the changes of thermo-electric quality occur as secondary effects of changes of magnetism.

To examine whether this is so, simultaneous measurements of the magnetic and thermo-electric effects of stress in an iron wire were made, and also independent observations of the thermo-electric effects of magnetisation, without change of stress.

A comparison of these made it clear that stress causes change in the thermo-electric quality of iron directly, and not as a secondary effect of magnetisation. If the wire be completely demagnetised to begin with, and kept clear of all magnetisation during the application and removal of stress, the presence of hysteresis is not less marked than before. Experiments are given to show how the thermo-electric effects of stress are modified by the existence of more or less magnetisation of the wire; and conversely, how the thermo-electric effects of magnetism are modified by the existence of more or less constant stress. The influence of vibration in destroying the effects of hysteresis is investigated, and also the result of exposing the wire to the process of demagnetising by repeated rapid reversals of a continuously diminishing magnetising force, and it is shown that this process acts in the same way as vibration in destroying the effects of hysteresis. Residual effects of hysteresis are studied, as, for example, the difference which presents itself when a wire is magnetised after having been loaded strongly and then unloaded down to a certain constant state of stress, and, on the other hand, when the same state of stress has been produced by simply increasing the load; and it is shown that these residual effects are wiped out by vibration or by demagnetising by reversals.

With regard to the effects of stress on thermo-electric quality, it is clearly shown that if a somewhat soft wire be more and more strongly magnetised these effects become more and more similar to those which are found when the wire is hard-drawn, but not magnetised. A few experiments were made with wires of silver, copper, lead, magnesium, and German silver, but in none of these was hysteresis of thermo-electric quality with regard to load discovered.

Special attention is directed to a peculiar feature in the curves by means of which the experimental results are exhibited. In curves showing the relation of thermo-electric electromotive force to load, it is shown that any reversal from loading to unloading, or *vice versâ*, causes an inflection in the curve, the first effect of the new process being to continue the kind of change of thermo-electric quality that was going on before.

That this is not caused by any mechanical disturbance which the loading or unloading produces is shown by the fact that it occurs in an equally marked way after the molecules have been brought to a condition of stable equilibrium by vibrating the wire before beginning to load or unload. It is suggested that the effects of hysteresis, described in the paper, have a possible relation to the properties which Prof. Osborne Reynolds has recently shown to be possessed by granular media.

The experiments described in the paper are closely connected with those which were communicated to the society in January, 1885, under the title "Experimental Researches in Magnetism," and are now being published in the *Philosophical Transactions.* They were conducted in the Physical Laboratory of the University of Tokio in 1881-3, partly with the help of one of the author's Japanese students, Mr. S. Sakai. The results are given graphically, and are for the most part reduced to absolute measure.

* Abstract of a Paper read before the Royal Society on the 11th March, 1886.

† Published in abstract in the *Proceedings* Royal Society, No. 214, 1881.

‡ "*Proc.* Roy. Soc.," No. 216, 1881, p. 22.

ELECTRICITY IN THE FUTURE.

Mr. J. Johnston, in a paper recently read in America upon motors, says:—

The future electric station will be erected to utilise power in hundreds of ways not now thought of. Central stations should be made large enough to combine all the present methods of using electricity, with full allowances for future discoveries, for I believe electricity is in its infancy. By this strange and novel agency power will be used to do its share toward the support and advacement of the human race. We may yet know, in our time, what electricity is, for to-day we only know it is a power that shows itself by its manifestations. A professor in a college asked a student one day what electricity was. The student hesitated and tried to think of the correct answer, but in vain; it was of no use. He could not recall it, but in self-defence said, "I did know, but have forgotten." The professor replied, "This is terrible. The only man who ever knew what electricity was has forgotten the answer." Electric light and power stations will be erected in the future as large as our present cotton mills. The engines will be used in the daytime to run lines of shafting to furnish power for manufacturing purposes over the station. Power motors will transmit electricity all over our cities to run small machinery. Both arc and incandescent lights will be used. Perhaps storage may yet be a success. Electricity will be used to drive machiney, to produce ventilation, for heating purposes.

The exhaust steam will also be used for heating neighbouring buildings in cold weather. There is no need to expatiate upon the advantages to be gained from an economical method of transmitting power, the costly and persistent attempts of inventors and capitalists to get better methods are enough to prove their desirability. Many systems have been tried and found wanting. In electricity, thanks to the living inventors, we have a force into which power can be transformed, as by the wave of the magician's wand, a force which flows to any distance with the rapidity of lightning and the stillness of a ray of sunlight, and then at bidding resumes its original shape quicker than thought can follow it.

SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the meeting of this Society on Thursday evening, 11th inst., held in the Institution of Civil Engineers, Great George-street, Westminster, two papers by Profs. AYRTON and PERRY were presented, the one on "Economy in Electrical Conductors," which was read by Prof. AYRTON, and which we have printed at length elsewhere; the other, read by Prof. PERRY, on "Some Problems in Telpherage." Owing to the lateness of the hour the last-named paper was not discussed; and the third paper which had been announced for that evening, by the same authors, "Note on Magnetic Resistance," was postponed. But the reading of the first of these papers gave rise to a discussion, or rather altercation, which, although of no particular interest, was evidently enjoyed by the audience as a relief to the wearisomness of listening to a long, dry mathematical discourse. Without

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denying that the calculations embodied in the paper would prove suggestive and useful in certain conditions, the general opinion appeared to be that those problems which were really a difficulty for practical electrical engineering just now had been left quite as obscure as ever, perhaps more so, by the elaborate equations and tables travelled over that evening. Prof. FORBES, Mr. CROMPTON, and Dr. FLEMING spoke more or less in this sense; and the former protested also that the authors had wholly misrepresented or misunderstood Sir W. Thomson's statement with regard to the proper sectional area for a copper conductor used in transmitting electric energy; and that a large portion of the paper purported to be a correction of an error which Sir W. Thomson never committed. After Prof. PERRY's reading of the paper on "Telpherage," the usual vote of thanks concluded the proceedings.

ELECTRIC LOCOMOTION.

A lecture on this subject was given by Mr. A. Reckenzaun on the 10th inst., at a meeting of the East of London Association of Marine Engineers and Foremen, at the Poplar Town Hall. The lecturer prefaced his lecture by explaining the general principle involved in the production and transmission of electric currents, and after alluding to several instances of the successful use of electricity to railways, &c., in this country and abroad, he proceeded to describe more in detail the various methods resorted to by different inventors for transmitting the energy when once it has been generated. Attention was also specially directed to the mechanical details of construction of the complete propelling apparatus. Incidentally appropriating his remarks to his audience, Mr. Reckenzaun took occasion to point a moral by touching upon the advisability—one may say the *necessity*—to all mechanical engineers of obtaining a thorough knowledge of electrical science, "for electrical engineering is," he said, "rapidly becoming an important branch of *mechanical* engineering, and it is *through* the judicious combination of the experiences gained from each that electricity has made, and will continue to make, such rapid advances in practical utility in such many and various directions. Mechanical engineers are too apt to look upon electric locomotion as nothing better than an expensive amusement, and to exclaim against the process of first converting steam power into electric energy, then transforming this energy into mechanical power, basing their objection upon the loss thereby of a considerable percentage of the original available force in the course of this double, sometimes treble, conversion."

The lecturer went to the very root of this matter. Beginning with the efficiency of the dynamo, and following up the possible loss through resistances in conductors and motors, friction in motors, and gearing of, for instance, an electric tramcar, he proceeded to show most conclusively that in many instances it is more economical to convert steam into electricity, and use the latter for propulsion, than to apply steam direct upon a locomotive. A locomotive must, for obvious reasons, be *at least* as heavy as the vehicle it draws. By placing the electric motor under the car to be propelled, and which itself carries the passengers, we obtain two great advantages. We got rid of the great weight of the extra vehicle, weighing from six to ten tons, and which requires two-thirds of its power to move itself, while, again, we make use of the dead weight of the passengers and the motive-power mechanism to produce the necessary adhesion to the rails. Thus in a car whose motor receives its energy through conductors the motive power apparatus need not weigh more than half a ton, or, taking the system of storage batteries, with its extra ton of cells, we have a great gain over a steam locomotive or any other of similar weight. Considering that the tractive force must be proportionate to the load to be carried, it must be evident that, with so great a saving in dead weight, we can readily afford to lose a large portion of the energy in transmission and conversion. No one would be so foolish as to put a separate locomotive upon a tram line if he could place the motor on the car. Exceptional cases present themselves where a system of haulage has its advantages, such as in "telpherage"—the transport of goods along overhead rods carried upon posts—but even there the locomotive must possess special appliances for providing a sufficient "grip" upon the rods. Another instance was that of underground haulage in mines, where a number of small trucks must be moved, yet where separate motors to each truck would be highly inconvenient. It was, however, a strong point in favour of electric tramcars that the motor could be made to form part of the passenger-carrying vehicle.

The lecturer's concluding remarks had reference to the construction of electric boats.

The lecture was listened to with marked attention, and a hearty vote of thanks was moved by the president of the association, Mr. George Williamson, to Mr. Reckenzaun for his interesting and instructive address.

COMPANIES' MEETINGS & REPORTS.

The Telephone Company of Egypt (Limited).

The third ordinary annual general meeting of the shareholders of this Company was held on the 16th inst., at the offices, 14, Austin Friars, under the presidency of Lieut.-General A. Fraser, C.B., R.E.

The SECRETARY (Mr. Alexander B. Chalmers) read the notice convening the meeting and the minutes of the last meeting. The report of the Directors, an abstract of which has appeared in *The Electrician*, was taken as read.

The CHAIRMAN then moved the adoption of the report and accounts, and the declaration of the dividend recommended, at the rate of 5 per cent. per annum (to be applied, as stated in the report, as follows:—2 per cent. in final payment of the cumulative preferential dividend of 7½ per cent. for 1883, and 3 per cent. in part payment of the cumulative preferential dividend of 7½ per cent. for 1884).

Mr. G. B. FROST seconded the resolution, which was carried unanimously.

On the motion of Mr. FROST, seconded by Mr. THOS. LLOYD, Lieut.-General Fraser was re-elected to his seat at the Board, Mr. Frost expressing his conviction that the very satisfactory state of the Company was a great deal due to the successful management of the Chairman.

The CHAIRMAN, in acknowledging his reappointment, stated that his earnest desire was to carry on the working of the Company successfully. Hitherto he thought they had been very successful, but he must say that that was not due so much to the direction here as to their staff in Egypt. Mr. Evans had throughout carried on the business there very successfully, and was a man to be trusted. They did trust Mr. Evans, and on no occasion had he ever found that that gentleman had given them reason to suppose that their trust might not be continued in him. He would like to be able to let Mr. Evans know that the shareholders generally approved of the work which he had done, and of the work of the staff under him, which in the opinion of the Directors was entirely satisfactory.

Mr. HENTSCH then moved the re-election of the auditors of the Company, Messrs. Price, Waterhouse, and Co., at the remuneration of fifteen guineas.

Mr. FROST seconded the resolution, which was carried unanimously.

On the motion of Mr. FROST, seconded by Mr. HENRY GREWING, a vote of thanks was passed to the Chairman, and the proceedings then terminated.

National Company for the Distribution of Electricity by Secondary Generators (Limited).

The third ordinary general meeting of the shareholders of this company was held at the registered offices of the Company, 18, Warwick-street, Regent-street, on the 18th inst., under the presidency of Mr. William D'Oyly.

The SECRETARY (Mr. J. E. Pickering) read the notice convening the meeting, and the report of the directors, which has appeared in *The Electrician*, was taken as read.

The CHAIRMAN formally moved the adoption of the report and accounts.

Mr. J. DIXON GIBBS: I have much pleasure in seconding the motion, but I think, in doing so, that very few remarks are necessary to supplement the sense of the report itself. The business generally is improving, as you see, and in many directions we have good promise for the future. The amount referred to as having been received from the Banque d'Escompte for the current year—up to the 1st of February of this year—is only £1,087. That is the balance of 40,000fr., or £1,300, due for the year ended the 1st of February, 1886; but for the year ended the 1st of February, 1887, there will be a *minimum* of 100,000fr., or £4,000. That is the annual *minimum* for this year. With regard to the work done, the only addition that is worth noticing since the report was printed is the opening of a further portion of the Tours installation, which M. Gaulard has just returned from effecting most successfully. The apparatus is ready, and is going out for the Italian installations, which may be expected to be opened in the course of the next month. I think that that is all I need say in further explanation of the report, and I beg to second its adoption.

Mr. KENNETH MACKENZIE referred to the item in the balance-sheet of plant and machinery, £4,444, and asked how it was made up, as it seemed to him a very large amount.

The CHAIRMAN stated that it included three dynamos, two of which had been sold; the generators which were used in the installation on the Metropolitan Railway, the workshops, tools, &c.

Mr. MACKENZIE inquired how the valuation had been made, and whether it was upon the present or the cost value of the plant.

The CHAIRMAN stated that the cost value had been reduced and taken off.

Mr. GIBBS pointed out that since the date of the report two of the principal items embraced in the total had been sold—two large dynamos—and that would reduce the amount. The items had been taken at a very low value, and the amount shown included the plant they had at Turin.

Mr. GLOVER: You have written off £360 in the profit and loss account?

The CHAIRMAN: Yes.

Mr. MACKENZIE: It may be taken, then, that this is a fair amount of what the value is?

Mr. CAMPBELL: Not what it is, but what it was on the 31st of December.

Mr. MACKENZIE stated that the preliminary expenses were shown at £486, of which £54 had been written off. He wished to know whether the amount was in connection with the original formation of the Company.

The CHAIRMAN replied in the affirmative.

Mr. MACKENZIE asked why only £54 had been written off.

The CHAIRMAN: Because we cannot write it all off in one year. It is a necessary expenditure in the first instance. If we wrote off all these

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things at once we could not expect to show any profit. We have written off some this year, and we hope to write off a good deal next year.

Mr. GLOVER stated that more than 10 per cent. had been written off, and it seemed to him that if that amount were written off every year it would meet the case.

Mr. CAMPBELL pointed out that the universal practice was to write off so much a year.

The CHAIRMAN then put the resolution, and it was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. GUSTAV DUFRESNE, the following resolution was carried unanimously:—"That a dividend be paid on the preferred shares at the rate of 10 per cent. per annum from the respective dates of allotment to the 31st December, 1884, payable forthwith."

Mr. GIBBS proposed the re-election of the retiring Directors, Mr. D'Oyly and Sir James D. Mackenzie, Bart.

M. GAULARD seconded the motion, which was carried unanimously.

The CHAIRMAN having acknowledged his re-election, proposed a resolution confirming the appointment as a director of Mr. Gustav Dufresne to fill the vacancy caused by the death of Mr. Le Fez. The Chairman stated that the Directors had the power, under the Articles of Association, to make the interim appointment, but such an appointment had to be confirmed at the following general meeting. He, therefore, proposed the confirmation of the appointment of Mr. Dufresne, whom they had found of great assistance at the Board from his commercial knowledge and other qualifications.

Sir J. MACKENZIE, in seconding the motion, said he thought the Company were to be congratulated on the accession to the directorate of so able a coadjutor as Mr. Dufresne. They had been very much in want of the commercial element to which the Chairman had referred, and in Mr. Dufresne they had certainly got a very able and thorough business man to help them. Moreover, bearing in mind the general character of the Company, they were very much in want of a linguist, and in Mr. Dufresne they had the services also of an accomplished linguist.

The CHAIRMAN put the resolution, and it was carried unanimously.

On the motion of Mr. NURSER, seconded by Mr. LUDEZ, the auditor (Mr. J. H. Thornton) was re-elected.

Mr. CAMPBELL then proposed a vote of thanks to the Chairman and Directors—to the Directors for the able manner in which they had carried on the business up to the present time, having brought the ship into clear water, and given the shareholders a dividend, and to Mr. D'Oyly for presiding over them that day.

Mr. GLOVER seconded the motion, and said he thought the shareholders ought to be very much congratulated on the successful way in which the Directors had piloted the ship, especially in view of the depressed condition of electric lighting generally. If the electric lighting industry had been brighter, the Company would have had better returns than they had made. As it was, however, he thought the progress which had been made was very satisfactory, indeed.

The CHAIRMAN acknowledged the vote, and expressed regret that the attendance of shareholders had not been larger.

Mr. GLOVER said he did not think shareholders cared to trouble to attend a satisfactory meeting.

Mr. GIBBS said he had no doubt that that was the explanation of the thin attendance. In answer to Mr. K. MACKENZIE he added that the whole of the details of the Tours installation had been given to the Société d'Electriciens, and would be published *in extenso* in the next *Journal* of that society.

The CHAIRMAN stated that the first part of that installation was opened about two months ago, and the second section had just been opened.

Mr. GIBBS added that there were two circuits of 2,000 metres each.

The proceedings then terminated.

Direct Spanish Telegraph Company (Limited).

Report of the Directors for the half-year ended 31st December, 1885, to be presented at the general meeting of shareholders on Tuesday, the 23rd inst., at half-past two o'clock:—

The accounts show, after paying for the repairs of the new Bilbao cable (£2,959. 13s. 7d.) and providing for debenture interest, a balance to the credit of profit and loss of £1,449. 5s. 2d. The traffic receipts show an increase of £287. 14s. 9d. as compared with the corresponding half-year of 1884, and an increase of £1,111. 12s. over those for the last half-year. The repairs of the new Bilbao cable, the interruption of which was mentioned in the last report of the Board, were promptly and economically effected. The cause of this break, which occurred in very deep water, cannot be ascertained. The entire cost of these repairs, it will be noticed, has been paid out of the revenue for the half-year. The new Bilbao cable has, since the repairs, worked perfectly. The Marseilles-Barcelona cable has remained in excellent working order throughout the half-year. The Directors are arranging to have the original Bilbao cable examined in the course of this summer, with a view to ascertain its condition. The Directors propose to put £1,400 to the reserve fund, which will then amount to £9,800, and to carry £49. 5s. 2d. to the next account. Sir James Anderson and Mr. John Denison Pender are the Directors retiring by rotation, and, being eligible, offer themselves for re-election. The auditor, Mr. Herbert R. Duke, retires, and offers himself for re-election.

Swan United Electric Light Company (Limited).

Report of the Directors to be presented at the adjourned ordinary general meeting of the Company, to be held at the Cannon-street Hotel, on Tuesday, the 23rd inst., at one o'clock:—

The Directors remark that, as a copy of the last report of the Edison and Swan Company was sent to every shareholder, it is not necessary to allude further to the English business. The shareholders are aware that the Company is engaged in litigation with the German Edison Company and with the Continental Edison Company which control the Edison patents in Austro-Hungary, Belgium, France, Russia, Spain, &c. Believing it to be for the interest of all concerned that this litigation should be brought to an end, the Directors have spared no effort to arrive at some fair and equitable settlement with the Edison companies on the Continent. Negotiations have been carried on with this end in view; those with the Continental Edison Company are still in progress, but it seems as if in Germany the suits must be fought out. It will be seen on reference to the last balance-sheet that the loss which had accrued up to 30th June, 1884, amounted to £2,327. 7s. 9d., to which must be added that on closing the Paris Factory in 1884, £1,128. 14s. 8d., and by the fire at Lille, £1,094. 2s. 11d. The loss during the year ending 30th June, 1885, as shown by the profit and loss account, amounts to £6,258. 9s. 7d., which, added to previous loss, brings the total up to 30th June, 1885, to £10,808. 14s. 11d. The Lille and Cologne Factories were not in working order until the spring of 1885. During the end of 1884 and the early part of 1885 the Company had to purchase lamps to supply their customers. In spite of legal proceedings and most active rivalry the business of the Company improved in the quarter ending 30th September, and shows a favourable balance of £3,206. 0s. 5d., thus reducing the amount standing at debit of profit and loss at that date to £7,602. 14s. 6d. Heretofore the accounts have been made up to 30th June in each year; the Directors propose that the financial year shall in future end on 30th September, and for that reason they now present the accounts to the shareholders for fifteen months. The question of the distribution to the shareholders of the shares allocated to this Company in the Edison and Swan Company has received the most careful consideration of the Directors, but they find that such distribution cannot take place pending the legal difficulties before referred to. Messrs. J. W. Swan and C. H. Stearn, directors, retire by rotation, but, being eligible, offer themselves for re-election. The auditors, Messrs. Quilter, Ball, and Co., also offer themselves for re-election.

BUSINESS NOTICES.—Messrs. Eck, Callow and Co. notify that Mr. D. J. Callow retired from the firm as from the 3rd day of February last, and has no further connection with or interest therein. Mr. Cecil B. Callow is general manager.—Messrs. Frederick Young and Co. notify that Mr. D. J. Callow and Mr. M. A. Callow retired from the above firm as from the 3rd day of February last, and have no further connection with or interest therein. Mr. Cecil B. Callow is general manager.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. March 17.	Business Done Week Ending March 17. Highest.	Lowest.	
Anglo-American	34½, 35½	35½	34	
Do. Preferred	58, 59	58½	57½	
Do. Deferred	11½, 12½	12	11¾	
Brazilian Submarine	11⅜, 11⅝	11⅝	11⅜	
Cuba	10½, 11	11	10½	
Do. Preference	17½, 18½	—	—	
Direct Spanish	1½, 2	—	—	
Do. Preference	11½ 12	—	—	
Direct United States Cable	9⅝, 9⅞	9⅞	9 11-16	
Eastern Telegraph	11⅞, 12⅛	12⅛	11⅞	
Do. 6 per Cent. Preference	14, 14½	14 3-16	13¾	
Do. 5 per Cent. Debentures, 1899	104, 107	—	—	
Eastern Extension	13, 13¼	13 3-16	12 15-16	
German Union	9¾, 10¼	10	—	
Globe Telegraph and Trust	6⅞, 7⅛	7 1-16	6 15-16	
Do. Preference	18½, 13¾	13 11-16	13½	
Great Northern	14½, 15	15⅛	14⅞	
Indo-European	35½, 36½	35½	35	
Reuter's	6¾ 7¼	—	—	
Submarine	200, 210	—	—	x.d.
West India and Panama	¾, 1	15-16	⅞	
Do. 1st Preference	9½, 9¾	9½	9½	
Western Brazilian	7⅜, 7⅝	7 13-16	7⅜	
Western Union 7 per Cent. 1st Mortgage	117, 121	—	—	
Do. 6 per Cent. Sterling Bonds	93, 102	—	—	x.d.

TELEPHONES.

Companies.	Closing Prices. March 17.	Highest.	Lowest.	
Consolid. Telephone and Maintenance	15-16, 1 1-16	1	—	
Oriental	¼, ⅜	—	—	
United Telephone	12½, 13	12¾	12⅝	

ELECTRIC LIGHT.

Companies.	Closing Prices. March 17.	Highest.	Lowest.	
Anglo-American Brush Light (£7 paid)	3, 3½	3¼	—	
Do. (fully paid)	5, 5½	5 3-16	—	
Hammond Light (£3 15s. paid)	1-16, 3-16	—	—	
Swan	1⅜, 1⅝	1⅝	1 7-16	
Maxim-Weston	5-16, 7-16	—	—	x.d.

MISCELLANEOUS.

Companies.	Closing Prices. March 17.	Highest.	Lowest.	
Telegraph Construction	36, 37	39	37	x.d.
India Rubber, Gutta Percha, and Telegraph Works	23, 24	23½	22½	x.d.

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NOTES.

MONTEVIDEAN AND BRAZILLIAN COMPANY.—The ordinary meeting of this company is postponed from March 25th to April 7th.

THE CABLE FLEET.—We hear that the Eastern Extension Company's new ship, "The Recorder," reached Singapore on Tuesday last.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 19th inst. amounted to £3,134.

METROPOLITAN TRAMWAYS. — The North Metropolitan Tramways Company is applying to Parliament for powers to use electricity as a power for moving carriages on their lines in West Ham, East Ham, and Leyton.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 19th inst. were £2,549, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

OBITUARY NOTICE.—We regret to announce the death on Saturday, the 13th inst., of Mr. Robinson Kendal (Chairman of the West Coast of America Telegraph, and South of England Telephone Companies), at the age of forty-eight years. The cause of death was heart disease.

BOOK RECEIVED.—"Electricity Treated Experimentally, for the Use of Schools and Students," by Linnæus Cumming, M.A. This work is published by Rivingtons, Waterloo-place, London, and contains the substance of experimental lectures delivered to some of the senior boys in Rugby School.

ANOTHER ELECTRIC LIGHT BILL.—Lord Bury has introduced a second Electric Lighting Act Amendment Bill into the House of Lords. We have been unable as yet to obtain a copy of the Bill from the Queen's printers, who say it will not be ready for a few days. Hence we reserve any remarks we may have to make till the text of the Bill is before us.

SUEZ CANAL.—According to a telegram from Lloyd's agent at Ismailia, the "Carthage," lighted by electricity, left Port Said at eight o'clock on Monday night, passing through the Canal during the night, and arriving at Ismailia at 5 a.m. on Tuesday. We believe this is one of the first instances of steaming through the Canal during the night, and that it can only be done by the aid of the electric light.

THE BERLIN NATIONAL EXHIBITION IN 1888.—We learn from Berlin that the general feeling of manufacturers, engineers, and electricians, which for some time was rather adverse to the idea of another exhibition with all its attendant expenses and loss of time, is gradually giving place to a more enterprising spirit, and it is probable that the German manufacturers of dynamos, motors, and lamps will very largely exhibit.

THE INSTITUT ELECTRO-TECHNIQUE MONTEFIORE.—This University in Liége was founded, about two years ago, by M. Montefiore-Levi. It is intended to educate electrical engineers in the same manner as the Continental polytechnic schools are intended for the education of mechanical and civil engineers. The average number of lessons given on theoretical electricity is 70 per term, and that of technical electricity is 140 per term.

GREAT NORTHERN TELEGRAPH COMPANY.—The ordinary meeting of this company will be held in Copenhagen on April 21st. The following business will be submitted:—A report of the business for the past year, and of the condition of the cables and other property; production of the accounts and balance-sheet, resolution to be passed of the amount of dividend to be paid for the past year, and discharge given to the directors for the same period; &c., &c.

A PHOTOGRAPHIC INDICATOR DIAGRAM OF THE WORKING OF A PRIMARY CELL.—Messrs. Trowbridge and Hayes pass the current through a mirror galvanometer and photograph the image of a lamp on a revolving drum covered with sensitised paper. A curve is obtained which shows the variation of current strength as a function of time, and gives a clear idea of the falling off in current strength due to polarisation and other causes when the resistance in circuit is kept constant.

A STANDARD OFFICE FOR ELECTRICAL UNITS IN GERMANY. At the last meeting of the Berlin Society of Electricians, Prof. Rühlman proposed that the German Government be petitioned to legally define the electrical units now in use, and to establish an office for electric measurements where a legal standard of resistance should be kept, and used as a basis for standardising resistances supplied to the public. The proposal was seconded by Prof. Foerster and Dr. W. Siemens, and unanimously adopted.

THE POWER OF THE HUMAN EYE TO DETECT MINUTE TRACES OF COLOUR. — Interesting experiments have been made by E. L. Nichols on the quantity of colouring matter which must be mixed with a perfectly white powder (carbonate of magnesia) before the human eye can detect it. From these experiments it appears that red and yellow are most easily detected, 16 and 17 parts respectively being sufficient for detection when mixed with a hundred million parts of white powder.

TRANSMISSION OF DIFFUSED LIGHTS ACROSS A GAUGE SCREEN.—Langley observes in *Silliman's Journal* that the ratio of the open surface to the total surface of a screen formed of wire gauge corresponds fairly well with the percentage of diffused light which the screen allows to pass. This is also the case when several screens are placed close together, the intensity of the light decreasing in geometrical progression with the number of screens; but for concentrated light the reduction is much greater.

ARC LIGHTING IN BELGIUM.—There seems to be a wide field for arc lighting in Belgium if we may judge from the number of foreign arc lamps which were exhibited during the recent electrical exhibition at Antwerp. It is also interesting to note that out of the ten exhibitors showing a total of 250 lamps, only two were by Belgian firms, with only 62 lamps. The following is a lists of the lamps shown:—Brush 45, Zipernowski 20, Gramme 13, De Puydt 32, Jaspar 6, Pieper 24, Patterson 52, Spieker 32, Crompton 4, Piette and Krizik 22.

PRIMARY BATTERY FOR LIGHTING PRIVATE CARRIAGES.—Herr Vohwinkel, in Vienna, manufactures a primary battery which is intended to be placed under the driver's seat, and which gives a current of 18 ampere hours at 36 volts pressure. The cells are enclosed in a wooden box, 23in. by 8in. by 9in., and a switch is fitted to the driver's seat, by which the current can be interrupted. It is stated that there is hardly any local action when the switch is off. The cost of keeping alight three 7-candle lamps for nine hours (after which time the battery has to be recharged) is stated to be 2s.

TELEPHONES AND FIRES.—Another instance of the value of the telephone in cases of fire is to be noted in connection with the recent alarming fire at Lemberg. The fire originated at five o'clock in the morning, and immediately on its discovery

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the alarm was telephoned to the fire brigade, who arrived on the spot in time to save the building. The advantages of the telephone system were so apparent that the mayor of the town directed the superintendent of the exchange to call upon him with the view to its extension, which will increase by so much the business for the Telephone Company of Austria.

FIRE AT THE CAVALRY BARRACKS, BRIGHTON.—On Sunday night a fire broke out in the store room of the Cavalry Barracks, and, owing to a short supply of water, it rapidly spread, and got beyond the control of the regimental brigade. A trooper was therefore despatched to the Volunteer Fire Brigade Station, whence the alarm was sent by telephone to the other stations. The Hove Volunteer Brigade by this means was enabled to arrive at the fire within half an hour of the alarm being given, during which time the men were got together, horses procured, and a distance of about three miles covered.

SHIP LIGHTING.—Some time ago the London and Edinburgh Shipping Company issued specifications for the lighting by electricity of their steamer "Malvina," and the estimate submitted by H. Bennett and Co., of 45, Bothwell-street, Glasgow, was accepted. The installation consists of an Andrews patent dynamo, 68 twenty candle-power lamps, and one of Tangye's Soho engines. The lighting has been divided into four circuits, controlling respectively the saloon, second cabin, engine room, and holds. The steamer has been fitted throughout on the single wire system, and the result has proved entirely satisfactory.

ELECTRICITY IN MINES.—In a paper recently read by Mr. C. Roberts, at the Junior Engineer and Scientific Society, at Glasgow, the difficulties of lighting mines safely and effectually were dealt with, and Mr. Swan's self-contained miner's safety lamp was fully described. Mr. Roberts also entered into the question of blasting by the aid of electricity generated by a small hand dynamo, and described the application of electricity to signalling in mines. The paper concluded with a short review on the present state of the electrical transmission of power, and its application for working fans, pumps, and other machinery.

CALORIMETRIC DETERMINATION OF THE TRUE OHM.—We learn from a recent number of *Silliman's Journal* that Mr. Fletcher has attempted to calculate the value of the true ohm in B.A. units by measuring the heat developed in a wire by the passage of a known current during a given time. According to Joule's law the heat $Q = \frac{C^2Rt}{W}$, where C represents the current, R the resistance, t the time, and W the mechanical equivalent of a heat unit. He finds that W = 42,068,000 B.A. units, and that the B.A. ohm is ·9904 of a true ohm. This figure is considerably higher than the mean of the latest determinations in England and on the Continent, which is ·9887.

THE UNITED STATES.—The telegraphs of the United States are almost entirely in the hands of the Western Union Telegraph Company, which had in 1884 145,037 miles of line, 450,571 miles of wire, and 13,761 offices; the number of messages sent in 1884 was 42,076,226, the receipts 19,632,940 dollars, expenses 13,022,504 dollars, and profits 6,610,436 dollars. Including minor companies, there were altogether 164,000 miles of telegraph line open for public use in 1884. In 1884 there were 96,000 miles of telephone wire belonging to one company, with 307,010 telephones, and 906 telephone exchanges. Altogether it is estimated that in the beginning of 1884 there were 120,000 miles of wire for telephone use.

REGISTERED TELEGRAPHIC ADDRESSES.—In the House of Commons on Tuesday last Mr. H. Fowler said, in answer to a question of Mr. D. Smith:—"There are, the Postmaster-General tells me, several objections to the official publication of a list of registered telegraphic addresses, the chief among them being that inconvenience to the public would arise from messages being addressed to names which, although appearing in a periodical list, had ceased to be registered. Numerous alterations, I should explain, take place in the register every day, some names being altered, and others withdrawn. I may add that certain persons strongly object to the publication of their registered addresses." On Thursday night Mr. Labouchere was to ask a question in the House as to the expediency of reducing the fee for registered telegraphic addresses in provincial towns to one half.

THE HEFNER-ALTENECK STANDARD FOR LIGHT.—Dr. Bunte has recently experimented with Hefner-Alteneck's standard lamp, burning amylacetate by means of a solid wick 8·3 millimetres in diameter, and has added certain improvements by which the height of the flame can be more accurately adjusted. He has also observed that the purity or otherwise of the atmosphere in which the lamp burns has a very marked influence on the amount of light given out. Photometric rooms are generally so closed up from all sides that ventilation is imperfect. Special attention should be paid to this point, as the lamp will only give one standard candle if burning in a quiescent and pure atmosphere. The wick tube must be eight millimetres wide and the total height of the flame must be forty millimetres, and the lamp should be left to burn at least for ten minutes before a measurement is taken.

EDISON AGAIN.—The *Daily News*, *Nottingham Daily Express*, and other papers, have commenced another "Edisonian" boom. This time Edison has worked out the problem of communicating with a train in motion, and, of course, is said to do this by some wonderful discovery of his into the unknown regions. When the whole thing is calmly discussed by the aid of diagrams the wonderful is not to be found, and only the ordinary apparatus appears. Who but the veriest tyro in electrical knowledge can subscribe to such sentences as—"The current generated on the train can be made to leap to the ordinary telegraph wires, thus obviating the necessity for having any special wire laid near the rails;" and, "The electrical message which Edison could shoot 50 feet through the air he now finds can be projected 580 feet without a wire or other conductor?" This is amusing, but it is not science.

LIGHTHOUSE ILLUMINATION.—Mr. Wigham, writing to *The Times* on March 16th, among other things, refers to the electric light in the following terms:—"Mr. Edwards repeats the conclusions of the Trinity House, and, making no mention of gas, states 'that for ordinary necessities of lighthouse illumination mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required electricity offers the greatest advantages.' So far from this being the case, the investigations of scientific men unconnected with the Board of Trade or the Trinity House, the two institutions being practically one, will prove that for great headlands the electric light is the worst that could be used for effect, and the greatest in expense; that for ordinary lights of sufficient power to show to the horizon in clear weather mineral oil is the cheapest; but that for great headlands and other important stations where the clear weather light requires to be augmented for foggy weather, the cheapest and by far the most powerful light is that of gas."

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THEATRE ROYAL, MANCHESTER.—This installation was made in December, 1882, from which time it has worked without the slightest hitch. In January of last year the Manchester Edison Company were requested to enlarge the installation, and so put incandescent lamps in the footlights, in order to do which it was necessary to remove the gas fittings; the confidence of the lessee had not been sufficiently strong to allow this at the outset. The lamps, which are of the Edison type, have been running about 6,000 hours; there are still many of the original ones in use, and none of the renewals have given out yet. The dynamos are four Edison 250 light machines which are worked at varying loads as scenic effects may require. During the whole time the commutators have not worn more than $\frac{1}{32}$in., and the wear of brushes has only been $\frac{7}{8}$in. each. In November, 1884, the installation was again extended in order to light the Comedy Theatre, which has been done with equal success, and a few months ago a large set of Elwell-Parker accumulators was added for the lighting of a warehouse and a concert hall in the vicinity from the theatre plant.

THE LIGHTING OF THREE RAILWAY STATIONS AT ANTWERP.—Some time ago tenders were invited for the lighting of three railway stations at Antwerp by arc lamps, and now the *Chronique des Travaux Publiques* publishes the result. The distribution of the lights was left to the parties tendering, the only condition being that no part of the floor space should have less light than $\frac{1}{50}$th carcel, equal to about 0·15 English candles. It is not stated how this illumination was to be measured. Only two electrical companies tendered—the Société Electrique in Brussels with 29 Brush lamps, having a total intensity of 33,500 candles, and the Thomson-Houston Company, with 43 lamps, having a total intensity of 25,800 candles. The cost of the plant was to be £4,600 and £5,200 respectively, and the price to be paid for running the installation £1,900 and £1,940 per annum respectively. The Antwerp Société Continental (Gas Company) offered to instal 146 gas lights, giving a total of 14,000 candles. The cost of gas pipes, and lanterns, and burners was to be £2,400, and the yearly expenditure for gas, £1,900. Therefore, with the same yearly working expenses electricity will give twice the amount of light as compared with gas.

DOMESTIC LIGHTING BY PRIMARY AND SECONDARY BATTERIES COMBINED.—M. Hospitalier, in *L'Electricien* of the 20th inst., describes his own private installation, which is so small that it would not pay to use a steam-engine or gas-engine in the usual way. The installation consists of six lamps, varying in candle-power from three to twelve, but all requiring a pressure of 10 to 11 volts. The current required by the three-candle lamps is 1·2 ampere, and that required by the twelve candle lamps is 3 amperes. There are six secondary cells connected in series, and wires lead from the five connections, and from the two terminals of the battery to a board, where they are joined to seven contact studs. The poles of the primary battery are joined in a similar way, with two switches placed on the same board, and by setting the switches so as to establish connection with any two particular contact studs, the secondary cells comprised between these points are charged. As a rule, three out of the six cells are charged at a time, the position of the switches being changed every morning and every evening. The primary battery consists of bichromate cells of one litre capacity each.

PATENT OFFICE PRACTICE IN THE UNITED STATES.—Those of our readers who have taken out patents in the United States will probably all agree that the way is beset with difficulties. The invention may be absolutely new, useful, and a proper subject for a patent, yet if the would-be patentee is not a citizen of the United States some difficulty will surely crop up. With their own countrymen the American examiners seem to be by far more easy going. Thus we find in the Official Gazette of the United States Patent Office for March 9th, 1886, a patent which closely resembles the original English patent of Varley for compound winding of dynamos. The number of the patent is 337,778, and the only point of dissimilarity with the modern compound machine is in the name. Instead of calling his invention a method for making dynamos self-regulating, the inventor calls it a regulator for dynamo-electric machines. One of the two horseshoe magnets constituting the field is wound with shunt wire, the other with main wire. The latter is considerably smaller than the former, and is called a detractor. It would from this appear that a new name for a part of the machine, and a misleading title for the whole, are sufficient to make a bad patent pass safely under the critical eye of the learned examiners in Washington.

THE LATE RAILWAY ACCIDENT ON THE RIVIERA. — Our contemporary *Electricité* points out that if means of communicating from the station with railway trains in motion had been available, this disastrous accident could have been prevented as soon as the station master had discovered his error. The immense importance of Gilliland's system of telegraphing to and from moving trains naturally suggests itself to the reader. But before this invention is perfected and actually introduced on every railway many years may elapse, and meanwhile station masters will have to rely on the old and time-honoured staff system. It seems incredible that an accident of the kind which has just taken place on the Riviera should happen at all. There is only one staff for each section of a single line, and no driver is permitted to start (notwithstanding any orders from the station master) unless he is in actual possession of the staff. Our French contemporary enjoins electricians and financiers to exert themselves in devising some electrical inventions by which similar railway disasters should be rendered absolutely impossible. It seems that *Electricité* does not know that already two years ago Mr. Willoughby Smith brought before the Society of Telegraph-Engineers and Electricians a suggestion to establish electrical communication with moving railway trains by means of inductive influence between two coils.

TELEPHONE LITIGATION.—As a good deal of interest is taken in the electrical, as well as in the legal, world on this subject, it may interest our readers to hear that there appears to have been some foundation for the rumours that the United Telephone Company (Limited) had taken active steps to stop the sale of valve telephones by the New Telephone Company (Limited). On Saturday last the case of the United Telephone Company *v.* Fleming, an action for infringement, came before Mr. Justice Chitty in court. Mr. Fleming had filed affidavits stating that, though he once had bought two Butler transmitters, the only transmitters he had ever used or sold were numerous valve telephones, purchased by him from the New Telephone Company. As that company had indemnified him against all claims for infringement, he claimed that it should defend the action brought by the United Company. This the New Telephone Company stated by their counsel they were perfectly prepared to do. The United Company, however, refused the challenge, and their counsel then stated that they were not suing Mr. Fleming in respect of the valve telephones, but in respect only of the Butler transmitters, which, according to the statement, he had never sold. Mr. Justice

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Chitty, on learning that the United Telephone Company declined to include in this action the valve telephone, directed the pleadings of the United Telephone Company to be altered so as to make it clear that they did not attack the New Telephone Company's instruments.

ELECTRIC LIGHTING IN TOURS.—A central station for the distribution of electricity by Gaulard and Gibbs secondary generators was opened two months ago in Tours. The last number of our contemporary *Cosmos* contains a detailed description of the opening ceremonies, and also some data on the plant erected, from which we take the following :—Power is supplied by two Weyher and Richemond steam-engines, one of 150 horse-power, running at 70 revolutions per minute, the other of 100 horse-power, running at 80 revolutions per minute. The power is transmitted by link belting to a counter shaft, and thence to the two Siemens alternating current dynamos type W_{100}. These are excited by the D_2 continuous current dynamos. The speed of the main dynamos is 500 revolutions per minute, which gives 16,500 reversals of current in the same time. With the full exciting power they develop an E.M.F. of 2,500 volts, but at present 1,250 volts are used, the current being at present 22 amperes. The mains are laid in underground troughs, and consist of 19-strand 65 mm. wire insulated by rubber, ozokerite, and tarred hemp. It is contemplated to erect 10 secondary generators; but at present only four are in use. Each consists of six primary and six secondary coils, the former being placed in series, the latter in parallel, so that the ratio of conversion is about 1·24, giving a secondary current of about 50 volts and 125 amperes. The four generators absorb each $5\frac{1}{2}$ amperes, and are placed in parallel on the mains. If the figures given by *Cosmos* are correct, the efficiency of conversion would be the ratio of 50×125 to $5\frac{1}{2} \times 1250$, or about 90 per cent.

FINSBURY TECHNICAL COLLEGE.—At a meeting of the City and Guilds of London Finsbury Technical College Old Students' Association, held on Wednesday, March 10th, at the College, Leonard-street, Mr. H. Newman Lawrence in the chair, Mr. W. T. Pettigrew (vice-president) read a very interesting paper on "Lighting of Railway Trains." The author spoke of the importance of the question of efficiently and economically lighting railway carriages, and the necessity of some radical improvement in the present general system. He gave his opinion that railway managers and engineers have very naturally hesitated in entering upon the heavy expense of lighting their carriages upon any other than the ordinary system lest to-morrow a newer and better one than they have adopted should present itself. The different systems of lighting were then enumerated as follows :—The ordinary roof lamp, burning rape or roof lamp oil ; the mineral oil roof lamp, burning highly refined and high-flashing petroleum ; ordinary coal gas ; coal gas compressed ; coal gas compressed and enriched ; oil gas, and electricity. The author then gave a detailed account of the different systems, the construction of the lamps, candle-power of the different lights, and particulars of the oil or gas used, and apparatus and fittings to the carriages. The system of lighting by oil-gas, as fitted to the Metropolitan and Metropolitan District Railways, and altogether fitted to over 3,000 carriages in Great Britain, was then fully entered upon, both as regards the manufacture of the gas and the apparatus and fittings to the carriages. On the subject of the electric light in railway carriages, the many systems on the different railways were described and contrasted, and mention was made of the brilliancy of the light and the conspicuous advantage over other lights, of putting out and relighting so readily without having to apply a light to each lamp. The costs of the various systems were also compared. In the discussion which followed Prof. S. P. Thompson, D.Sc., contributed some useful and interesting information on the subject. The following gentlemen also spoke :—Messrs. A. Chatterton, B.Sc., W. S. Crawshay, L. Davidson, W. Dickson, O. Haes, A. W. Herbert, H. Newman Lawrence, A. C. F. Webb, and N. R. Wilson.

COMPRESSED AIR AS MOTIVE POWER FOR DRIVING DYNAMOS.—In Paris there is a society owning and working a number of clocks distributed throughout the town. These clocks are worked by compressed air, and as it was found necessary to remove the compressing machinery from the centre of the town where most of the clocks are situated, the company were forced to lay down an underground air main, $3\frac{1}{8}$in. in diameter, which happens to pass along some of the boulevards and other principal streets. Advantage is therefore taken to supply motive power not only for the clocks, but for other purposes; and in the Café de Paris there is, according to our French namesake, *l'Electricien*, an installation worked by compressed air from the pneumatic main. The pressure employed varies between 45 to 60lb. per square inch, and the power is regulated by a throttle-valve interposed between the air main and an air vessel, or reservoir, from which the engine is supplied. The object of this reservoir is to prevent the strokes of the piston of the air-engine from being felt in the main. Since the air in passing through the engine works expansively its temperature becomes considerably lowered, and to prevent the formation of ice and snow, which would have the effect of clogging the valves and passages, the air must be heated to about 50deg. centigrade before being admitted to the cylinder. This is done by passing it through pipes heated by a gas stove. The dynamo employed is of the Gramme type, giving 35 to 40 amperes at a pressure of 100 volts when driven at 1,400 revolutions per minute. It receives motion by a belt from the fly-wheel of the compressed air engine, which runs at 150 revolutions. The power is charged for at the rate of 70 centimes (about 7d.) per horse-power hour, but the method of making up the account is, to say the least of it, very primitive. It simply consists in attaching a counter to the engine shaft, and charging according to the total number of strokes made by the piston. With a water engine this would be perfectly fair, but with an engine which works by the pressure of an elastic fluid, first more or less throttled, then heated, and then expanded, the amount of power obtained is in no way proportional to the total number of strokes made during any given time. Whatever be the merit or otherwise of this system of charging for power, the price charged is quite prohibitive, and we cannot well see how it could be otherwise. Of all the known means of transmitting energy to a distance, compressed air is the most wasteful. It would have been much more economical to lay a pair of cables at the same time as the pneumatic tube was laid, and work the lamps in the Café de Paris direct by a dynamo in the compressing station.

PHOTOGRAPHY BY A LIGHTNING FLASH.—According to Prof. E. J. Houston, Mr. Albert S. Barker, of Philadelphia, has succeeded in taking two very fair photographic negatives of outside objects while illumined by no other light than that of a single lightning flash. These photographic views were taken at 7 p.m. on Thursday, October 29, 1885, near Philadelphia. The night was excessively dark, the wind strong, and the rain heavy. The camera was placed in an open window, with the slide drawn. The lightning flash came in less than one minute, when the slide was returned. The plate holder was then

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reversed and suitably placed for a second exposure. The plate was one of the highly-sensitive gelatine films. Mr. Barker developed the plates the same evening. From their behaviour he rated the actinic effect of the light as equal to that obtained from an exposure of about $\frac{1}{300}$th part of a second in bright sunlight. The popular impression as to the duration of the lightning flash is that it is practically instantaneous. From the experiments of Wheatstone and others with the rotating disc, the duration of the flashes measured would vary apparently from the $\frac{1}{1000}$th to the $\frac{1}{10000}$th of a second. Others estimate the duration of the flash as even shorter than these figures. It is very doubtful if the average severe flash in this latitude does not endure or continue for a very much longer period. Despite the popular belief to the contrary, the author has frequently observed the motion of foliage when illumined by no other light than the lightning flash. This would not of course be the case if the flash were even approximately instantaneous. It is a very significant fact that in the photographs of Mr. Barker the foliage shows unmistakable evidence of having perceptibly moved during the period of exposure; thus showing that it was by no means instantaneous. It is to be hoped that Mr. Barker, or some other photographer, will repeat these exposures under the following conditions, viz., to make the exposure while the camera is sharply focussed on moving foliage, or a rapidly rotating wheel, while illumined by a lightning flash, so as to determine more definitely the duration of the flash. In the case of the lightning flash, the large percentage of blue rays would of course render the plate more sensitive to the extremely short exposure by practically prolonging the same, since the ordinary photographic chemicals now employed are especially sensitive to the blue portions of the spectrum. It would appear from the facts developed by the photographs of Mr. Barker that the method of measuring the duration of the lightning flash as adopted by Wheatstone and others, which consists essentially in endeavouring to detect by the unassisted eye the change in position of a rapidly moving wheel, or other object, while illumined by the flash, might be greatly improved by substituting for the eye the sensitive photographic plate, since the latter is apparently far more sensitive than the eye. Should photographic pictures of a rapidly rotating wheel, whose rate of motion was known, be taken while illumined by a lightning flash, the displacement of the image on the negative would give far more reliable data for calculating the duration of the flash than the methods heretofore employed. Mr. Barker's photographs, therefore, are not only interesting as showing how extremely sensitive the photographic plate may be made, but are also of interest as throwing some light on the possible duration of the lightning flash.

ELECTRIC HOUSE LIGHTING BY PRIMARY BATTERIES.— Numerous attempts have been made to obtain a successful incandescent electric light by means of secondary storage batteries, charged from dynamos, but, owing to the small amount of electricity obtained in comparison with the power required, these batteries have so far, we believe, not been proved to be a commercial success. One of the latest improvements in this direction has been the production of a primary battery, named the "Aurora," which is really an improved bichromate solution battery, having a power which is remarkable for its size, and the advantage of not polarising, heating, or evolving any deleterious gases. Each cell holds about a gallon of exciting fluid, which, we are informed, is made by a peculiar patented process, and is the important factor in the success of the battery. Two large carbon plates are placed outside of the porous cup, and in the latter is inserted the zinc, of a special form to expose a large amount of surface. In the porous cup is put water, which in a few hours becomes charged with the exciting fluid from the outside jar. The zincs are well amalgamated to prevent local action. We recently attended a private exhibition of a complete system of house lighting by the use of this battery, as introduced into the residence of Mr. Henry V. Parsell, of this city, and were agreeably surprised to notice the power of the battery in sustaining with beautiful brilliancy several incandescent lamps, and the facility with which they could be lighted. In a room adjoining Mr. Parsell's laboratory, together with a fine large screw-cutting geared lathe and other highly polished steel tools, were located on shelves twenty eight cells of battery. None of the tools were corroded or in the least damaged by reason of fumes emanating from the battery. In addition to its use as a lighting battery, it was shown that it could be employed as a motive power for driving the large lathe, by means of a small Cleveland electric motor, developing a force equivalent to one-third of a horse power. A special switch was provided, which enabled the operator to utilise at once the force from one to twenty cells, as might be needed. No difficulty was experienced in rapidly boring, with large-sized drills, through blocks of the hardest wood 2in. thick. Many novel uses of the lamps were shown; half a dozen 6-candle lights placed in a cabinet of minerals, when turned on, instantly lighted it perfectly. In a dome in the ceiling of the laboratory, painted blue and decorated with gilt stars, were hidden from view a group of small lamps. These when lighted produced a very soft, radiant effect, giving a light similar to that of a full moon on a clear night. A special small Edison lamp of 40 candle-power placed in a magic lantern was next lighted, and the pictures in the lantern thrown upon the screen. The brilliancy of the light compared favourably with the lime light. A peculiar dark room ruby light, for photographic purposes, was shown, and also the perfect adaptability of small lamps for illuminating safely dark closets. Adjustable lights with neat porcelain shades mounted on a stand for desk use or for reading purposes, as well as suspended lamps, were also exhibited. We were informed that about thirty lamps of varying candle-power had been distributed about the house, but the full power of the battery was not capable of sustaining more than eight sixteen candle-power lights at a time. It was expected that for ordinary use but half a dozen lamps would be used at once. In comparison with the results obtained, the loss of zinc in the battery is exceedingly small. Mr. Parsell stated that although the zincs had been constantly immersed and the battery had been working for two months, the zincs had lost but a few ounces each in weight. He had replenished the battery but once during that time, having used it every day. The advantage of having electricity generated for general use in one's house so easily, and with so little trouble and danger, as this battery appears to furnish it, cannot be over estimated. We understand its practicability has been so well established by prolonged experiment that a new company, with a large capital, called "The Household Electric Light Manufacturing Company," of New York, has been organised for the purpose of putting in electric plants in private residences and caring for the batteries, keeping the same in order. The small lamps, their attachments, and the battery are supplied by the Stout Meadowcroft Company, of this city. The above is from the *Scientific American.* We give it as a fair specimen of "Primary Battery" literature from the other side of the Atlantic, and may say that the praises of the inventor are not warranted by the teachings of science.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 208.)

Action between a Magnet and a Magnet, or between a Magnet and a Conductor supporting an Electric Current. The Closure of the Electric Current. Its Necessity.

The section before the last being preliminary to the subject of the stresses, and the last section being of a perfectly abstract nature, the one to follow this will be on the magnetic stress in general, as modified by differences of permeability and other causes. The present section is of an intermediate nature. Though dealing with the magnetic stress outside magnets, its principal object is to direct attention to the vexed question of the closure of the electric current; which I endeavour, as far as I can, to bring down to a question of definition.

Let us forget, if possible, for a time, all knowledge of the electric current—or rather, let us make no use of it. Suppose that we are fully acquainted with the mechanical actions of rigid magnets upon one another. That there is probably no such thing as a perfectly rigid magnet (that is, in the larger theory, an unmagnetisable magnet, whose permeability is unity, or the same as that of the enveloping medium) is immaterial. We suppose there is. Except that the argument would be more complex, it would not alter our general conclusions to take a magnetisable magnet.

We may put any collection of little rigid magnets together to form a complex magnet, having any distribution of magnetisation. Its external field of force is to be got by observing the mechanical force it exerts upon one pole of an exceedingly weak and slender magnetised filament, uniformly and longitudinally magnetised, so as to localise its poles strictly at its ends. Upon the basis of the definition of a unit pole, that it repels a similar unit pole at unit distance with unit force, we can map out the external field of force. Let F be the magnetic force intensity, the force on a unit pole placed in the field, or rather, n times the force on a pole of strength n^{-1}, when n is infinitely great. F is subject to the conditions

$$\text{div.F} = 0, \qquad \text{curl.F} = 0,$$

outside the magnet. The lines of F start from the surface of the magnet, proceed in curved paths through the air, and end upon its surface again at other places.

If we describe a closed surface in the air, completely enclosing the magnets, of whose position within the surface we might be ignorant, we should be entirely unable from our examination of the field outside the surface, to determine the interior distribution of magnetisation, or even to determine the situation of its poles, that is, the distribution of the imaginary magnetic matter, to which, if we ascribe self-repulsive force according to the inverse square law, we may attribute the external field. We might ascribe F to a distribution of matter σ over the surface itself, of total quantity zero; or to a distribution of a vector quantity γ over the surface in closed lines, producing external F according to another law, viz., $\text{V}f\gamma$ = force due at a point Q to the element γ; f being the force at γ due to unit matter at Q; or to combinations of both σ and γ, one of which is unique, inasmuch as it produces no internal field. Contract the surface until it reaches the magnet itself. Then we may ascribe the external field to σ, or to γ, or to combinations, definitely, on the surface of the magnet, or in its interior in various way, but not definitely. The distribution of magnetisation is, *a fortiori*, still more undiscoverable, for there may be distributions corresponding to no magnetic matter, giving no external force.

But, making use of our knowledge of the effect of building up a magnet from smaller ones, we may suppose that the magnetisation is known. Let the vector magnetisation be I, and its convergence be ρ, the density of the magnetic matter. Then

$$\text{div.F} = 4\pi\rho, \qquad \text{curl.F} = 0,$$

fully determine F. It is of considerable practical utility in theoretical reasoning not to treat the surface and the volume densities separately, but to include them both in ρ, the volume density. Thus, if a magnet be quite uniformly magnetised, there is, strictly speaking, no ρ. The convergence of I is on the surface. But, by supposing I not to cease abruptly on reaching the surface, but gradually, however rapidly, through a thin surface layer, we make the matter have a space distribution, of the same total amount per unit of surface as the surface distribution it represents. We can always derive the surface expressions from those of the volume with great ease, when we want them; whilst our work is much simpler without them when we do not want them.

The resultant force between any two magnets may now be easily represented. $\Sigma F_2\rho_1$ is the resultant force on a magnet whose matter density is ρ_1, due to another magnet whose polar force is F_2. And $\Sigma F_1\rho_2$ is the force of the first magnet on the second. (We need not trouble about the forces of rotation at present, which are nearly as simply represented.) These are equal and opposite. Also $\Sigma F_1\rho_1 = 0$ and $\Sigma F_2\rho_2 = 0$; a magnet cannot translate *itself* (or rotate itself either). So if $F = F_1 + F_2$, making F the actual force of the field, the forces on the magnets are $\Sigma F\rho_1$ and $\Sigma F\rho_2$ respectively.

Describe any closed surface separating one magnet from the other; let the first magnet be inside. The force on it may, as in the last section, be represented by the surface integral

$$\tfrac{1}{2}\Sigma(\sigma\text{F} + \text{V}\gamma\text{F}),$$

if $\sigma = \text{NF}/4\pi$, $\gamma = \text{VNF}/4\pi$, N being a unit normal from the inner to the outer region. Or, which is the same thing, by

$$\Sigma\{\text{F.(NF)} - \text{N.}(\tfrac{1}{2}\text{F}^2)\}/4\pi,$$

in terms of the Maxwellian stress.

The following is the process of showing that this stress gives rise to the required mechanical forces. The quantity summed up is the vector stress on the plane whose normal is N. If we fix the direction of N, its divergence is the N-component of the force per unit volume, by the principles of varying stress.

Now $$\text{div.}\{\text{F.(NF)}\} = (\text{NF})\text{div.F} + \text{F}\nabla(\text{NF}),$$

and $$\text{div.}\{\text{N.}(\tfrac{1}{2}\text{F}^2)\} = \frac{d}{dn}\left(\tfrac{1}{2}\text{F}^2\right) = \text{F}\frac{d\text{F}}{dn},$$

if n be length measured along N.

Also, $$\text{F}\left\{\frac{d\text{F}}{dn} - \nabla(\text{NF})\right\} = \text{NVF.curl.F},$$

so, S being the vector stress on the N plane,

$$4\pi.\text{div.S} = (\text{NF})\text{div.F} - \text{NVF.curl.F},$$
$$= \text{N}\{\text{F.div.F} - \text{VF.curl.F}\},$$

or, $$\text{div.S} = \text{N}\{\text{F}\rho + \text{V}\Gamma\text{F}\},$$

if $\Gamma = \text{curl.F}/4\pi$. This being the N-component of the force, the force itself is

$$\text{F}\rho + \text{V}\Gamma\text{F}$$

per unit volume; or, since $\Gamma = 0$, the magnetic force of the magnets being polar, simply $\text{F}\rho$ per unit volume.

The length of this process depends upon our wishing to develop the term $\text{V}\Gamma\text{F}$. If it were not for that, we would see at once that

$$\nabla(\text{NF}) = \frac{d\text{F}}{dn}$$

when F is polar, N being in any direction, and so get the force $\text{F}\rho$ immediately.

The question now asks itself (remembering that we are ignorant of the electric current), what is this Γ, whose vanishing cuts the work short at the beginning, in our case of F being polar. Can it really represent any physical magnitude?

It is defined by curl. $\text{F} = 4\pi\Gamma$, and is necessarily zero in the case of magnets. It indicates *closed* lines of F, which are impossible with a strictly polar force in all space Γ is a vector, and is necessarily closed. This is a mathematical consequence of its definition.

Furthermore, whilst F, as a polar force, with $\Gamma = 0$, is a special kind of distribution of a vector, if we allow Γ to be not zero F becomes of the most general type possible, *any* distribution of force, or any field of force, without the polar limitation. Given the divergence, and the curl of a vector, the vector itself is fixed, if it is to vanish at infinity.

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Supposing, then, we allow that Γ can exist, we can predict what the mutual force between a magnet and it will be. Let there be Γ in a certain region, outside of which there is only ρ, therefore only magnets. The resultant force on this region is equivalent to VΓF per unit volume. We cannot localise the force, we can only know its total amount. It is necessarily ΣVΓF. The reason we cannot say that VΓF is the force on unit volume is that Γ is necessarily closed, and so we cannot work down to a unit volume without having current in the external region as well, which is against our previous knowledge.

So far Γ has a merely speculative existence. It is got by making the assumption that there can be closed lines of magnetic force. Admit that there can be, the laws of Γ follow. Γ is necessary closed. The magnetic force it produces at Q is $\Sigma f\Gamma$ if f be the force at Γ due to unit matter at Q. The force between one Γ and another and between Γ and ρ follow, viz., that the resultant force on any region containing ρ and closed Γ is

$$\Sigma(\rho \mathrm{H} + \mathrm{V}\Gamma\mathrm{H}),$$

H being the actual intensity of the field due to all the ρ *and* Γ.

Now, we do know what Γ is, under certain circumstances. By the researches of Ampère, the father of electrodynamics, who gives his name to the père, the unit of electric current, we know that Γ measures the density of current in a conductor when it is steady. His researches were conducted in a very different manner, and are indeed very difficult to follow, like most novel researches, but the results are exactly these, without his hypotheses as to the action between different elements of a current. We virtually measure the strength of current in a conductor, when we use a galvanometer, by the line integral of H round a current, and that is the amount of the quantity $\Gamma = \mathrm{curl.H}/4\pi$, passing through the line of integration.

Also, steady currents are closed. So far, then, we identify Γ with the conduction current.

But *our* Γ is closed under any circumstances. We know also that conduction currents are not always closed; for instance, when we charge a condenser. We still measure the conduction current in its transient state by Γ. We do so by the continuously changing instantaneous magnetic force if the charge or discharge be slow enough; otherwise, by the ballistic method, which is virtually the same. Γ being then unclosed in the conductor, has necessarily its exact complement, to close it, outside the conductor, *i.e.*, our Γ has, though it may be only called current when in the conductor.

But our Γ, being identified with current when in a conductor, both in steady states when the current is closed in the conductor, and in transient states when it is closed through the dielectric, and this Γ in the dielectric being related to the magnetic force in the same way as if it were conduction current, why should we not call it electric current also? As it demonstrably exists, we see that the closure of the current is reduced to a question of a name. It would be positively illogical not to call it electric current.

To sum up.

1. From magnetic knowledge only, there should be no closed lines of force in the space outside magnets.
2. If we admit the existence of closed lines of force, or say generally, if we admit that the line integral of the force in a circuit in air can be finite, we arrive at a vector quantity Γ having the property of being closed, and we can find the mechanical force between it and magnets or other Γ, and can thus definitely measure Γ.
3. This Γ we know to be conduction current, when steady.
4. But in transient states, conduction currents are not closed (or need not be).
5. But a part of Γ still measures the conduction current.
6. The other part, the complement of the conduction current, is outside the conductor, continuous with the conduction current, and closing it.
7. Then why not call it electric current?

We see that it is not a question for experiment, for no amount of experimenting could alter this reasoning, but of definition, an agreement to call a certain function of the magnetic force always by one name, viz., the electric currrent, which, if in a conductor, heats it and and wastes energy, whilst in a non-conductor does not, energy being stored potentially. It is, of course, needless to add that this current in a non-conductor is Maxwell's current of displacement, $\dot{\mathrm{D}}$, the rate of increase of the displacement, whilst $\mathrm{E}\dot{\mathrm{D}}$ is the activity of the electric force E to match, and $\frac{1}{2}$ ED the stored potential energy of displacement.

NOTE on equation (32*a*), p. 207, Jan. 22, '86.—For mnemonical purposes, the following is a concise form of this equation. The potential being given $= \mathrm{P}_0$ over a closed surface, due to matter or current within or on it, the potential P at any external point Q is

$$\mathrm{P} = -\Sigma p^2 \frac{d}{dn}(\mathrm{P}_0/p), \quad . \quad . \quad . \quad . \quad . \quad . \quad (32a)\ bis.$$

if p be the potential due to unit matter at Q, and n be length measured along the normal outward.

(To be continued.)

MUNCASTER CASTLE INSTALLATION.

At a time when the sun has passed the equator, and when a genial warmth has replaced the wintry temperature of the early part of the month, our readers can hardly realise the troubles and privations undergone in a journey to Muncaster Castle on the first two days of March. Cumberland under a canopy of snow presented a scene at once weird and beautiful. From the experiments carried out at Messrs. Mather and Platts, at Manchester, we were bound to Ravenglass, the nearest station to Muncaster. Our colleagues at Manchester little knew the lucky escape they would have when parting for the South and for home on Saturday, Feb. 27th. When the hospitable doors of Mr. W. Glover closed on us on Sunday night the wind was bitterly cold, and snow was beginning to fall, while on Monday morning the storm had commenced in stern reality. March, indeed, came in like a lion. Before starting northward we paid a hurried visit to two of Mr. Glover's works; we hope shortly to visit the third, and to give a description of the same. Starting from Manchester we soon found that the snow would assert its supremacy. Everywhere it was drifting, and the train service was becoming more and more deranged. Despairing of getting to Ravenglass we decided to stop at Ulverston, and again fate was in our favour, for between Barrow and Ravenglass two trains were snowed up. One line was with difficulty got clear on the Tuesday, and we had the pleasure of passing the snowed-up carriages on the other line. Arrived at Ravenglass, we found it a little seaside village without much accommodation for man or beast. It seemed that even when within a mile or so of our ultimate destination that we must turn back, but fortune, in the shape of a two-horse buggy, in which was seen the genial face of Mr. Richardson (Messrs. Robey and Co.) came to our aid, so that the last difficulty was overcome. The correspondents of the political papers undergo privations to obtain authentic news, and we think we can claim that the correspondents of the technical press do not spare themselves in order that they may verify the facts of an installation. It is easy to accept descriptions and give them publicity, trusting wholly for their correctness to the sender, who is generally a greatly interested party, but not so easy to verify the facts before subscribing to their accuracy. The gentlemen who met at Muncaster Castle on March 2nd must always feel some sort of contempt for the "drawing room soldiers" who take things on trust. However, Edinburgh, London, Lincoln and Manchester met amid the snow drifts, and proceeded to explore the castle. If we have adverse criticism to make, let us make it at once. Opinions may differ, and do differ considerably, upon questions relating to ornament and light, and, therefore, we may be allowed to say that the fixed standards in the hall seem to us far from being the best means of placing the lights; and although candles are always placed upon the table in the dining room, it would be better to have more lamps. Two clusters could be placed overhead, and kept in perfect harmony with the arrangement of the room. Lastly, so far as suggestion is concerned, we think the whole benefit of the

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light is not obtained upon the table in the billiard room. Have lamps with the top half silvered been tried, and, if so, with what result?

The greatest admiration was expressed for the electrolier in the library, and without doubt it is one of the most elegant and tasteful that we have ever seen. It is made of polished copper in the form of sprays and flowers, each flower carrying an incandescent lamp. The lamps are so arranged that one-third, two thirds, or the whole number can be switched on or off, as desired. The electrolier was made by Messrs. Edmondson and Co., of Westminster, who carried out the whole installation, from designs of Mr. Ferguson, the architect of the castle. From the castle to the engine house was the next move, in order to try some experiments with the engine, and more especially with its governor.

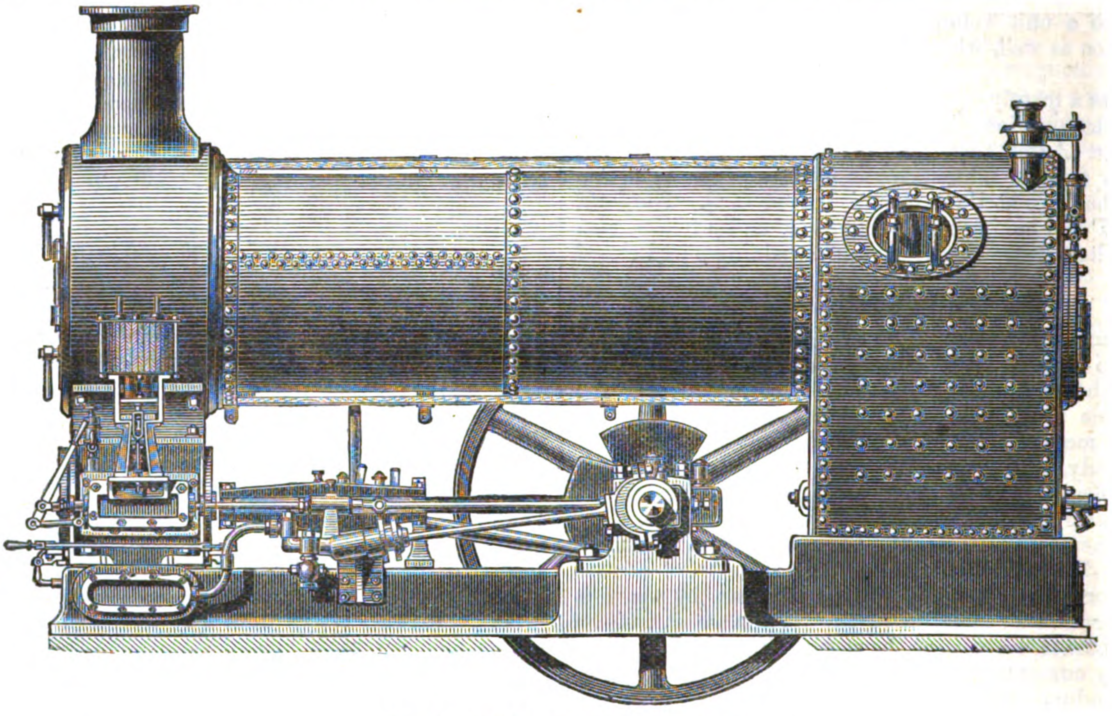

FIG. 1.—"Robey Engine." Side View.

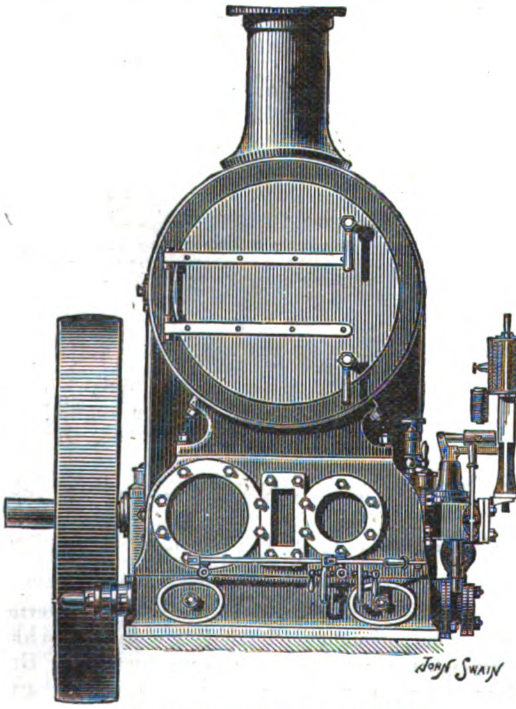

FIG. 2.—"Robey Engine." End View.

The experiments, which were highly successful, were made to test the efficiency of the Richardson-Nevile electric regulator, which was exhibited and described at the summer meeting of the Institute of Mechanical Engineers held at Lincoln last August (*vide Electrician*, Vol. XV., pp. 235-6, 252-3).

The installation at Muncaster Castle, as we have said, was made by Messrs. Edmondson, and consists of two Elwell-Parker shunt-wound dynamos, each capable of supporting 120 lights of 16 candle-power. Practically the whole of the castle is lighted by electricity.

The machines are driven by a steam engine of 14 horse-power nominal, made by Messrs. Robey and Co., of Lincoln. The engine has two cylinders, 8$\frac{3}{4}$in. diameter by 14in. stroke, fixed on a massive cast-iron base plate, which also supports the boiler, and is of the type now so well known as the Robey engine (Figs. 1 and 2). The engine is not only used for driving the dynamos, but also for sawing wood, &c., for the estate, for which purpose it is fitted with an ordinary high-speed governor, controlling a double beat valve. When used for electric light purposes this governor does not come into play, the engine being then controlled entirely by the Richardson-Nevile electric regulator.

It may be well to refer briefly to the combined governor, which is illustrated in Figs. 3 and 4. The regulating part of the governor consists of a double solenoid magnet M M, placed vertically, and wound with insulated copper wire, within which works a double core, A A. To the cross piece D, at the bottom of the cores, is linked the long arm of the lever E, the short arm of which presses downwards upon the spindle of an ordinary double-beat Cornish equilibrium valve that controls the admission of steam to the chest. For incandescent lighting in parallel the wire on the bobbins is placed in shunt circuit between the main leads, and the size of wire is adjusted to the electromotive force it is desired to maintain between the mains; when the proper electromotive force is attained the cores A A are suspended within the solenoids by their attraction. Since the resistance of the solenoids is fixed, any increase in electromotive force causes an increased current to flow through them, and consequently the cores are attracted with increased force, and are drawn upwards, thereby closing the equilibrium valve a little, and reducing the steam supply until the electromotive force has been brought down again to its proper value. So far as here described the governor is very imperfect, allowing of too much variation (especially under variable boiler pressures) in electromotive force, which is very destructive to the existence of the lamps. To remedy this defect the small

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cylinders B and C seen in Fig. 3 are added. Each cylinder is fitted with a small piston and rod, the tops of which engage with a lever L, but on opposite sides of the fulcrum. The cylinder B communicates by means of a small pipe with the boiler, and the cylinder C with the steam chest. This arrangement very accurately neutralises the effect of a variation in the boiler pressure by opening or closing a little the throttle valve, as the case requires, and in that way a constant steam chest pressure is maintained, whatever the pressure in the boiler may be, so long as it is enough to keep the machines going at their proper speed. The cylinders B and C can be moved nearer to or further from the fulcrum of the lever, so that the resultant effect of their differential action can be accurately adjusted. The centrifugal governor shown is added for safety in view of a wire breaking or of the main driving belt leaving the pulley; of course, if, as in this case, the engine is used for other work, it is absolutely necessary that a centrifugal governor be applied in addition to the electric regulator. A high testimony to the value of the apparatus consists in the fact that though it was set to work over six months ago and left in the hands of an ordinary engine driver it has continued to work most satisfactorily, and was found by the gentlemen who witnessed the all the lights were turned on the effect on the engine was equally instantaneous. These experiments were many times repeated, always with the same results. It is certain that a momentary change must really take place when large numbers of lamps are switched in or out, else no effect could be produced upon the engine, for "out of nothing nothing can come." To ascertain this amount was the next object. The voltmeter was kept in the circuit and carefully watched by one gentleman, another as carefully observing the time, whilst a third manipulated the switch. A signal being given, the lamps on all switched out, the voltmeter needle makes a sudden upward movement, instantaneously changes its direction, and comes gradually to rest again. The maximum variation, and that only for an instant, was not more than 5 per cent., and the whole time occupied by the regulator in shutting off steam from the engine and bringing the E.M.F. to its normal intensity did not exceed 3 seconds, the speed of the engine being reduced from 143 to 123 revolutions within that time. Similar experiments were then tried with the accumulators, with equally satisfactory results. The next test was made to show how far the boiler pressure could be raised without affecting the speed of the engine, the load remaining constant. Steam was allowed

Combined Electrical and Centrifugal Governor.

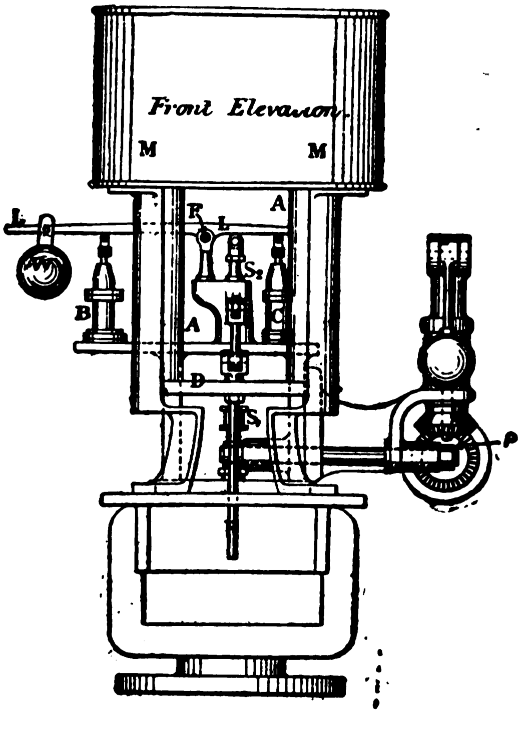

Fig. 3.

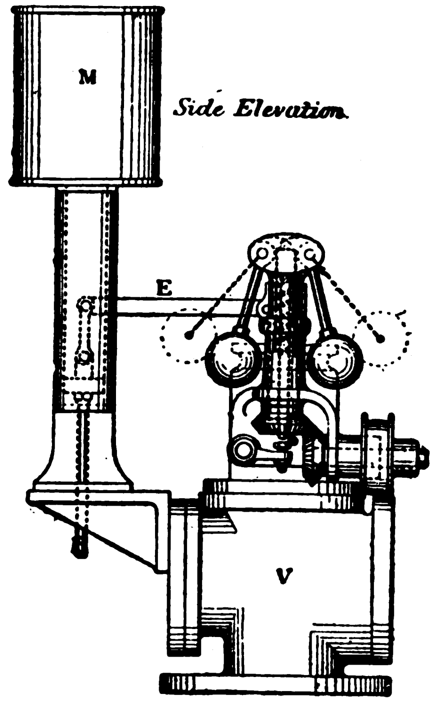

Fig. 4.

tests in a state of the highest efficiency. The tests made at Muncaster were as follows:—The engine was started, running the dynamo with one lamp only burning in the engine room. A man was then sent round the castle to turn on the lights, as would be done in ordinary use, while the voltmeter was carefully watched to see the effect upon the electromotive force. This remained constant at 120 volts, it being impossible to detect the slightest variation. The engine, as the lamps were turned on, increased in power and speed, the intensity of each light remaining constant. Groups of lights on the brackets and electroliers in tens, twenties, and thirties were turned in and out without making any perceptible change in the electromotive force. A most severe test—probably the most severe possible—was then tried. All the lights which could be lighted were turned on, and by a switch in the engine house all turned off at once. Simultaneously with turning the switch the click of the slide valve was heard in the steam chest, showing conclusively that all the steam had been shut off, and that the engine was running empty. Examination of the voltmeter before and after showed no difference in the E.M.F. When to run down from 75 to 40lbs. pressure and run again to 80lbs., the speed of the engine remaining constant within one revolution. It was remarked that, though the regulator acted with most remarkable promptitude or suddenness, there was not the slightest tendency to overrun or hunt.

We certainly must congratulate Messrs. Robey and Co. upon the success of these experiments, and Mr. Richardson for the admirable governor he and his colleague have devised.

The Economy of Small Arc Lights.—German *savants* continue to experiment with small arc lamps, which German electricians are continuously bringing forward. Dr. Valler, in Hamburg, has recently examined the small arc lamp of Scharnweber, intended for a current of about 4 amperes, and he finds that at an angle of 45 degrees to the horizontal, 483 English standard candles are obtained with an expenditure of 196 watts. The average between the horizontal intensity and that at 45 degrees is 315 candles, obtained with an average expenditure of 200 watts. This is at the rate of 0·63 watt per candle.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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ANSWER TO CORRESPONDENT.

A. F.—*We cannot call attention to the note you refer to, as by so doing we should be perpetuating the evil. We quite agree with you as to the bad effects and the undesirableness of such notes.*

THE SIXPENNY TARIFF.

If any proof were needed of the general popularity which the SIXPENNY TARIFF for INLAND TELEGRAMS has already secured, it would be furnished by the ASSOCIATED CHAMBERS of COMMERCE. That body of commercial representatives are not famous for modesty in preferring their claims to consideration, or for moderation in propounding their grievances. A deputation from them waited on the POSTMASTER-GENERAL a short time ago to state their views on the new tariff, and also as to the charges for telephonic communication. With regard to the latter we have nothing to say at present, further than to agree with Lord WOLVERTON that the question is a great deal too large and complicated to be dealt with, except by a gigantic addition to the business of the Department entirely beyond the sphere of practical politics just now. But with respect to the first-named subject, namely, sixpenny telegrams, all that the deputation could find fault with was the, in their opinion, excessively high charge for registering addresses. Subsequently a memorial reached the POSTMASTER-GENERAL from Yorkshire, equally limited in the scope of its complaint, proposing only that this charge should be reduced from a guinea, the present fee, to five shillings. With the exception of the customary newspaper correspondence in the autumn months, most of which came more properly under the head of facetiæ than of serious remonstrance, this is substantially the main fault that has been found with the scheme inaugurated last October; and this only from one class of the community, the class not solely or chiefly considered when the change was advocated. From the general public there have been extremely few complaints, and none at all of the two essential features of the tariff, its brevity and its taxed addresses.

Now this we consider is a great triumph for the originators of the reform; and our testimony ought to count for something seeing that we were never very ardent believers in the blessings of cheap telegraphy, though for many years we were the only newspaper that consistently advocated the abolition of the free addresses. The reduction of the initial charge from one shilling to sixpence was a bold step, which, if popularity is proof of success, has succeeded perhaps beyond expectation, especially as it was coupled with such a reduction in the number of words as might not improbably have been resented as irksome and unnecessary. All has gone smoothly, however; the public have cut down their telegrams to the sixpenny dimensions with pretty general regularity, and when this could not be accomplished they have paid the trifling extra charges with commendable good temper. Added to this, the traffic has been disposed of with wonderful celerity; at least, we infer as much from the absence of public complaints on this score, a circumstance which, considering the enormous increase in the number of telegrams we know to have been despatched, reflects much credit on the POSTAL TELEGRAPH ADMINISTRATION, as well as on the sagacity of those who stood out against the alternative scheme of free addresses with a tariff so low as sixpence.

Had free addresses been conceded, it is highly probable that the provisions made for dealing with the augmented business would not have satisfied the requirements to nearly the same extent. But besides this there must have been a greater loss to the revenue as well as an increase in outlay on plant and in working expenses. As it is we hear of a not inconsiderable falling off of receipts during the past six months, compared with a corresponding period under the old tariff. This is no more than was expected, at all events by persons who took trouble to consider the matter seriously. It will be a good while, we fear, before the British Public double the number of their telegrams all round; and until they are nearly doubled the revenue will show a deficit—a diminishing deficit, no doubt, but still a deficit; and the expenditure we may be sure will go on swelling in nearly the same proportion. Neither in private firms nor in public departments can vast additions to the business be made without a commensurate addition to office expenses. Already we hear of demands being made for increased pay in consequence of the increased work and responsibilities thrown upon the staff of *employés*; and we do not see how these demands can be justly refused on principles which prevail in all ordinary business relations. It was perfectly well understood by those who agitated for this great change in the telegraph system that it was made for the good of the country generally, that the Post Office had no business to earn a profit, and that the benefits conferred on the public by a cheap system of communication by telegraph would far outweigh any loss that might be inflicted on the Post Office revenue. We need not argue these points; but the most fanatical exponent of a cheap Governmental service will hardly venture to assert that servants employed by the Government ought to accept these high philanthropic, philosophic, or politico-economic motives in lieu

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of pay. Granting the general good, and dismissing, as we have done, the theory of working for profit, it is the more evident we must pay the public servants adequately for enabling us to confer this boon on the community.

No doubt when it comes to be known exactly how the finances of the telegraphs stand in regard to the new tariff, the usual flood of suggestions for mending matters by making them worse will be poured in. We can only hope that they will be dealt with in the same firm and business-like manner with which the deputation from the ASSOCIATED CHAMBERS OF COMMERCE were disposed of the other day. Undoubtedly the charge for registering addresses seems a very high one ; and if it covered only the act of registering, it would, of course, be preposterously so. But it ought to have been pretty evident, even to the Chambers of Commerce, that addresses are registered by persons only who receive many telegrams, and that many references to the registry involve a great deal of time and labour. We have no practical knowledge of the system, and do not mean to have any. The outlay of a few halfpence at most will make our address perfectly intelligible, and will ensure swift delivery without a preliminary search in the Post Office Register of Addresses. But for those who fancy the luxury of having an unintelligible code for their addresses with the idea of saving something the system will last so long as they find it pays. By some it is evidently thought to be a good advertisement ; and it is cheap for them at a guinea. For the rest it is a barefaced evasion of the taxed addresses ; and the request to reduce the charge to five shillings means neither more nor less than that the Department shall abrogate that rule in favour of particular firms. We are glad to see that the POSTMASTER-GENERAL met the request with a flat refusal, pointing out that the system of registered addresses, which may be fairly legitimate for expensive foreign telegrams, is an abuse of the cheap inland tariff, and involved the Department in a loss far exceeding the total number of guineas charged. Perhaps after this the gentlemen represented by the Chambers of Commerce will be discreetly silent on the subject of registered addresses, otherwise they may find that a class privilege which they are now enjoying at the public expense will be in danger of being withdrawn altogether.

CORRESPONDENCE.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : In his last letter Prof. Thompson seriously protests against the persistency with which I adhere to what he is pleased to call a wrong definition. Persistency is certainly not a fault of Prof. Thompson, for so soon as he finds that one of his statements has become untenable he qualifies it by saying he meant something else. Thus, in his letter published in your issue of the 5th of March he speaks of a magneto machine having a critical speed. To a plain-speaking man a magneto machine means one with permanent steel magnets, but in his last letter Prof. Thompson explains that he means a machine with steel magnets, provided with series-exciting coils—that is, a dynamo which is partly self-exciting. Only if that was his meaning from the beginning he ought, in his definition for critical speed, to have included the resistance of the series coils. This he has not done. He spoke of the " line that represents (by the tangent of its slope) the armature resistance." But even accepting his latest definition I cannot help thinking that the term "critical speed" is ill chosen. I should prefer to call it the proper working speed, for it is that speed at which the machine will do what is claimed for it by the term self-regulation, *i.e.*, it will keep a constant pressure at its terminals. I shall not follow Prof. Thompson in his elegant simile concerning the sole of his boot, as I prefer to discuss scientific subjects in scientific language ; but dropping all squabbles about phraseology, I shall, with your permission, go back to the point where I had originally the misfortune to differ from Prof. Thompson. It was not a question whether the term critical speed was correct or not, but it was a question whether constant current motors could be made to run at a constant speed if constructed on the basis of Prof. Thompson's formulæ. I shall endeavour to show that a constant current motor cannot be made self-regulating in the way suggested. The condition of supply is : a constant current, whatever may be the counter electromotive force of the motor. The working condition is : a constant speed under a variable load. Since the current supplied to the motor is constant, the work obtained from it must be approximately proportional to the electromotive force at the brushes. That is to say, the heavier the load the greater must be the E.M.F., provided the condition of constant speed to be fulfilled. From the latter condition it also follows that the torque must be proportional to the work done, and therefore it must be proportional to the E.M.F. Since the torque is the product of armature current and strength of field, we find that the latter must be approximately proportional to the E.M.F. Now, Prof. Thompson classifies motors for constant current under these three headings :—

(*a*) Magneto motor, with shunt regulating coils.
(*b*) Series motor, with shunt regulating coils.
(*c*) Series motor, with long shunt regulating coils,

and he proceeds to say that the latter two, with differential winding, are the only important cases.

From his formula it appears that the shunt coils must tend to demagnetise the field. A motor constructed on these principles would therefore have the weakest field when the E.M.F. at the brushes is a maximum, and the strongest field when the E.M.F. is a minimum. Now, I have just shown that the speed can only be maintained constant if E.M.F. and strength of field are approximately proportional, and since the differential winding recommended by Prof. Thompson has exactly the opposite effect, it seems tolerably certain that his motor will not be self-regulating. But even were both series and shunt coils to magnetise the field in the same direction, the motor would not be self-regulating ; for an increase in the load would in the first instance slightly reduce the speed, and this would subsequently result in a reduction of the strength of the field, which again will lower the speed, and so on. A motor so constructed would work in a condition of unstable equilibrium.—Yours, &c., THE WRITER OF THE REVIEW.

Erratum.—In Prof. Silvanus Thompson's letter in our last issue, on p. 369, lines 21, 22, first column :—

For " It has nothing whatever to do with the original and incorrect statement of my reviewer ; the right figure should be 736," *read,* " It has nothing whatever to do with the original and incorrect statement of my reviewer *that* the right figure should be 736."

PARALLEL DISTRIBUTION BY TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : In the course of the last few weeks Prof. Forbes, as well as some other gentlemen, have ventilated the advantages and disadvantages of connecting inductional transformers for alternating electric currents in multiple arc with the high tension mains.

We are glad to see that some of the writers on this subject agree in their views with those held by us for a considerable time, and also that the scientific side of the question is becoming the subject of investigation by men of science. But as to the industrial side of the question we beg to state that the connection of alternating current transformers with their primary coils in multiple arc, and supplying the same with alternating currents of sensibly uniform tension, is the subject of our English patent No. 3,379, dated 16th March, 1885, and that the same is patented to us in Germany and in most industrial countries of the world. We are also determined to

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defend our rights relative to this invention with all the means provided by law.

We request you kindly to publish this communication in the next issue of your esteemed journal.—Yours, &c.

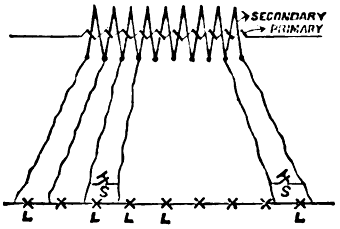
CHARLES ZIPERNOWSKY,
MAX DERI,
OTTO TITUS BLATHY.

Budapest, 18th March, 1886.

THE GROSVENOR GALLERY INSTALLATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 5th inst. you say, in relation to the Grosvenor Gallery Installation, "the lamps are connected to the transformers in parallel, and as they are turned off the potential rises." Could this not be obviated by connecting up the lamps to transformer as in the following sketch:—



S, S are *short-circuiting switches*, there being one to each lamp, L. Lamps L are connected on "the three wire system," and want *very few volts* and *large current* to work them (such as Bernstein's for example). A branch for one lamp (only) is taken off every sixth convolution or so.

Switching out one lamp by shortcircuiting it would, as I understand it, *have no effect whatever* on the other lamps in the series; it would also be highly economical.

The construction of these transformers would readily allow these connections to be made. I should also say that there would not be much difficulty in modifying the present connections to lamps.

If you think the above suggestion worth inserting in your valued paper, I shall feel obliged.—Yours, &c.,

A. M. TAYLOR.

3, Clifton-terrace, Southsea, Hants., March 18, 1886.

MISTAKES IN ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. James Johnstone's question under this head in your previous number, I must first point out to him that the expression—"development of electricity"—which he quotes from my article means neither more nor less than the *production of electrification*, viz., the process by which the distribution of electricity is altered in such a way as to enable it to produce visible effects. I should have thought that this was sufficiently clear from the paragraph immediately preceding the expression quoted.

Now, in order to produce such an alteration in the distribution of electricity in any system a certain amount of work must be done, and, therefore, some source of energy is requisite.

Again ("Maxwell's Electricity," Vol. I., page 46, second edition), if a small body, carrying a small charge, e, be moved from one given point, A, to another, B, along a given path, it will experience at each point of its course a force, R e, where R varies from point to point of the course. Let the whole work done on the body by the electrical force be E e, then E is called the total electromotive force along the path A B.

From this definition of electromotive force we see that a quantity of energy may be expressed as the product of the two factors, quantity of electricity and electromotive force. It is, impossible, then, that electricity should be energy, as it is only one of the factors of energy, the other factor being electromotive force.

Mr. Johnstone's misapprehension evidently arises from his confounding electricity with electromotive force. From his statements, "According to this paragraph, electricity is a *force*, and it is *energy*," it would appear that he supposes force to be the same thing as energy, and also that he is unaware that electromotive force is not a force at all, but that it has been so named owing to the analogy between its action on electricity and the action of force upon matter.—Yours, &c.,

G. W. VON TUNZELMANN.

FRANKLIN INSTITUTE TESTS ON INCANDESCENT LAMPS AT PHILADELPHIA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to Mr. Tatham's letter in reply to ours on the above tests, we are sorry that we did not see Mr. Wahl's letter in the New York *Electrical Review* of June 20th, which, however, we consider a somewhat weak denial in face of the strong assertions made by the *Electrical Review*.

Mr. Tatham states in his letter:—"In the conduct of the tests the cardinal principle was to do right and also to *avoid all appearance* (the italics are our own) of wrong-doing. To this end a code was adopted and judges selected, with the full concurrence of the contestants, and nothing was concealed from the parties in interest. The contestants were invited to inspect and did inspect every step in the progress of the tests, and their experts compared the photometric measuring powers of the judges with their own."

We are surprised at the Franklin Institute again making the above assertions. We beg most emphatically to deny that a code was adopted or judges selected with our concurrence. We deny that we were ever informed of what was in progress, and we were never invited to inspect, nor did we inspect any steps in the progress of the tests; nor had we experts to compare their photometric powers with that of the judges, but on the contrary, never heard a word of our lamps being tested until we saw in the London *Electrical Review* that the tests were practically over. Mr. Tatham is incorrect when he says the "boast of our lamps is that they are brilliant and cheap." To advocate them on account of their brilliancy would be manifestly absurd, and so far as cheapness goes, although our lamps are the same price to the general public as those of other makers, the trade are willing to pay and do pay a higher price for them than any other lamp. What we claim is that the efficiency of our lamps will be found considerably greater than that of other makers, while the life of our lamps compares very favourably with them.

With regard to the method adopted by the committee of running our lamps five volts higher than they were marked, we think that some statement should have been made of the fact that for some considerable time the lamps were run at from 25 to 32 candle-power, or an efficiency of about $2\frac{1}{4}$ watts per candle-power (mean horizontal intensity), and yet in their report the committee use the words "possibly received more than their proper E.M.F." In the face of the above, these words present a needlessly incorrect view of the case.

With regard to Mr. Preece's statements, he had ample opportunity of testing the lamps at the Wimbledon trials, where they were run for some considerable time, our lamps being, we believe, the only ones of which none broke the whole time. As for the statement that some of the lamps were sent over by Mr. Preece specially to be tested by the Franklin Institute, the following is Mr. Preece's reply to our letters:—

"Gentlemen: The lamps tested at Philadelphia appear to have been some of yours, sent by me to a personal friend, who omitted to give me the faintest idea of the purpose for which they were intended. Had he done so I should, of course, have told you. I had the pleasure of inspecting an installation recently where your 20-candle lamps have obtained an average life of 1,500 hours, and many of them are now 'alive and kicking' after 4,000 hours' work. They were 80 volt lamps, running at 79 and taking 73 amperes, or 56·7 watts each.—Yours faithfully, (Sgd.) "W. H. PREECE."

As we have every confidence in our lamps, we are only too

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anxious to have them tested in competition with those of other makers, and we shall be happy to subscribe £50 towards any tests such as mentioned lately by Mr. Crompton.—Yours, &c., WOODHOUSE AND RAWSON.

E.P. STORAGE CELLS.

The following interesting letter of Sir William Thomson to the secretary of the Electrical Power Storage Company will be read with interest :—

DEAR MR. DRAKE: Your storage cells have given me the greatest satisfaction. I have used 44 of them for my house lighting ever since I got them first charged up, within a few days after receiving them from you (Nov., 1885), and they have worked to perfection. It is the greatest possible comfort to us in the house to have the light with satisfactorily equal brilliancy at all hours of night or day and every day of the week. I have now cut off the gas at the meter, so that there is absolutely none used in the house. I have no oil lamps, and have not used so much as a single quarter of a candle within the last three months, as I have the electric light in every part of the house where light can possibly be wanted by night or day. I find by a little management of throwing off a few cells from the house circuit when the engine is going, and throwing them on when it is stopped, that there is no difficulty in keeping the potential at the house within 2 or 3 per cent. of absolute constancy.

I use a Clerk gas engine to drive the dynamo, and find that it is impossible to tell by the appearance of the lamps whether the engine is going or not. Before I had your secondary battery we could always see a pulsation of the lights in time with the revolutions of the engine. The absolute steadiness of the light which we now have is most satisfactory and pleasing.

I have six of your cells continually in use on my laboratory table, and they are charged according to need by joining them up parallel and putting them into the charging circuit; so that when they are being charged the engine is called upon to work against a potential of 45 cells, instead of, as usual, a potential of 44 cells. This makes scarcely a sensible difference to the engine; it merely lets it go a little faster and causes it to give a slightly smaller current. Of course, a sixth part of this charging current passes through each of the laboratory cells. I use these cells for laboratory purposes, sometimes keeping them joined in parallel and sometimes joining them in series, according to my laboratory needs. It is a great convenience to me to be able to get at any moment 180 amperes for testing and adjusting my electrical measuring instruments. With this varied and irregular use in my laboratory the six cells keep in perfectly good order. I suppose if I take care never to run them down too low they will keep in good order for years.—Yours truly, WILLIAM THOMSON.

16th March, 1886.

NEW ARC LAMP FOR SMALL CANDLE-POWER.

We illustrate in Figs. 1, 2, 3, and 4 a new arc lamp manufactured by Buss, Sombart and Co., in Magdeburg, which is intended for all cases where a small unit of light is required. It is claimed for this lamp that it can be placed either in parallel or series connection, and will work equally well in either case. The peculiarity of this lamp consists in a special feeding arrangement by which a too rapid descent of the upper carbon—a common failing in ordinary clutch lamps—is rendered impossible. The current enters at *p*, passes through the body of the lamp to the upper carbon, thence across the arc into the bottom carbon, from there through the electromagnet A and out at *n*. The top of the wheel frame, *a a*, constitutes the armature of the electromagnet, and in being attracted raises the rack rod and strikes the arc. In order that the lamp may feed, the train of wheels M, N, O must be set in motion, but it will be noticed that the latter wheel can only rotate through a limited angle, since one or other of the two pegs projecting from its face is arrested by coming in contact with one of the lappets *e e'*, attached to a spindle, P, which carries a comparatively heavy fly-wheel, Q. The usual shunt solenoid, B, in combination with a lever, H, and brake, I, operates the feed motion. When the wheel frame is first pulled up, I presses upon Q, preventing its rotating, but should the arc lengthen, and thus the power of the shunt-solenoid increase beyond its normal amount, the core C will be sucked further in, thereby raising the lever H and brake I, and thus allowing the fly-wheel to revolve in obedience to the pressure exerted by one of the pins in wheel Q upon one of the lappets on the spindle P. When the wheel Q has turned through about 90 degrees, the opposite pin comes into contact with the other lappet, whereby the rotation of the fly-wheel is stopped and reversed. After a further rotation of 90 degrees the second pin slips off the lappet, and the first pin is brought into contact with the first lappet, and so on, the motion proceeding step by step at a very slow rate until the shunt solenoid drops the lever H, thus arresting the oscillation of the fly-wheel Q. Since the latter is of considerable weight the to and fro motion can take place only slowly, and overfeeding should be almost impossible. The core of the shunt solenoid is provided with rings, *j j*, to prevent the air from passing too easily, and thus the motion of the core is steadied.

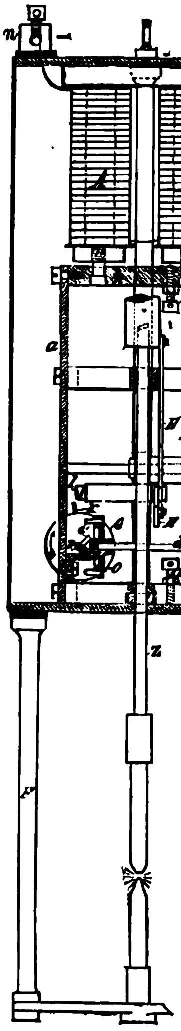

FIG. 1.

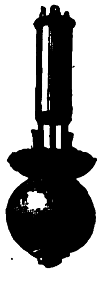

FIG. 4.

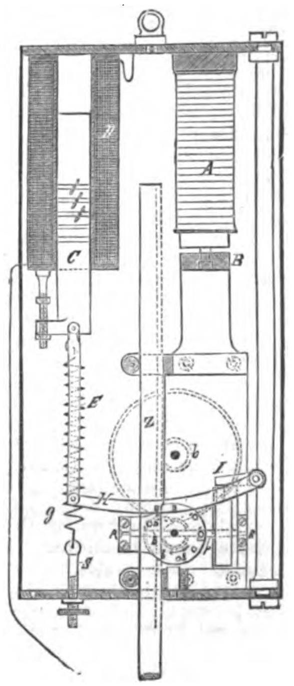

FIG. 2.

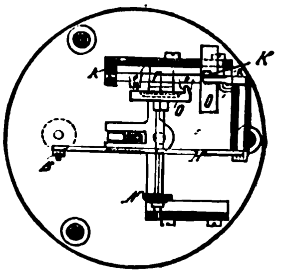

FIG. 3.

Dr. M. Krieg, of Magdeburg, has in the *Centralblatt für Elektrotechnik* published the results of a series of trials with these lamps, from which we abstract the following figures :—

Upper carbon (cored), 7 mm. ; lower carbon (solid), 6 mm.

Current in amperes.	Volts over terminals.	Length of arc mm.	Spherical candles.
4	48—49	2·5	198
3	48—50	2·0	119
2	47—50	1·8	76

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Thus a mean luminous intensity of 76 candles could be obtained with an expenditure of 100 watts electrical energy, or about 1·3 watt per candle.

DOMESTIC ELECTRIC LIGHTING.*

BY W. H. PREECE, F.R.S., VICE-PRESIDENT OF THE SOCIETY.

Electric lighting, on some distributive plan like that of gas, is still an event of the future, in England. Other countries (notably the United States), Germany, Austria, Italy, Belgium, &c., are ahead of us; but in the electrical illumination of our homes—the traditional castle of the Englishman—we are in advance of all other countries. The number of private residences now lighted by electricity is very considerable. The way in which men of wealth have constituted themselves into amateur electricians is very characteristic of this country. There is something about electricity, in all its practical applications, that renders it captivating. Its marvels excite the imagination, its powers astonish the mind, its ready adaptability encourages invention, and its easy control favours its employment for many purposes where mechanical appliances would, in many cases, be more suitable. Hence, men of means and of leisure have made its study a hobby. There is no purpose to which wealth can be applied more beneficial or praiseworthy than that of aiding the thrashing out of problems whose successful results lead to the greater comfort and happiness of the many. Pure air in our lungs means health in our bodies and energy in our minds. The success of domestic electric lighting is a great sanitary question, and its solution has a much greater significance than mere commercial rewards. Municipal authorities expend fabulous sums in preventing the contamination of our water, but no local power has yet attempted to remove the poison from the air we necessarily breathe with our present mode of artificial illumination. Electric lighting does not do this, but it stops the supply of the vitiating gases.

Now, the progress of electric lighting in this country has been very seriously checked by the inordinate mania for speculation that characterised the year 1882, and the terrible losses that ensued therefrom; but there has been a quiet, steady progress made, that has not been checked by restrictive Acts of Parliament, and has not been deterred by misapplied capital. I want to chronicle what has been done, and how it has been done. The pioneers of domestic electric lighting in England have been Sir William Thomson, Sir William Armstrong, Mr. Coope, Mr. Sellon, and Mr. Charles Moseley. Sir William Thomson used a gas engine, and worked his lamps direct from the dynamo, not only lighting his house, but his class room and laboratory in the University of Glasgow; Sir William Armstrong obtained his power from a waterfall in his grounds; Mr. Coope used a steam engine; and Mr. Sellon and Mr. Moseley relied on secondary batteries, obtaining their power from a gas engine. Their good example has been very largely followed, and there are now a great many private houses in all parts of the country thoroughly and efficiently lighted. In fact, electric lighting is becoming a fashion, and the only fear for its ultimate general success is its falling into the hands of the inexperienced and ignorant—one chief cause of its check in the past. I have not known a single case of failure where the installation has been undertaken by experienced men. There have been many disappointments where

"Fools rush in where angels fear to tread."

Electric lighting means the utilisation for illuminating purposes of a certain amount of energy, which has to pass through various stages and forms, from its dormant condition in coal and water to its active condition in a lamp. I propose to discuss the question in each stage.

The Motor.—Steam, gas, and water have been used as agents for the production of power, but petroleum has not yet had a trial in England, and wind is too uncertain to be relied upon. Water is the most economical when it has not to be paid for, gas the most convenient, but steam is the most reliable. Electric lighting by incandescence absorbs much power. Power is the rate of doing work or of expending energy. Mechanical engineers measure this rate of doing work by referring to an arbitrary and erroneous standard called the horse-power; but electricians have introduced a new standard, more scientific and exact, called the watt. The watt is the work done in one second by an ampere flowing through an ohm, and having, therefore, an electric pressure of one volt. The number of amperes multiplied by the number of volts gives the number of watts. A watt is equal to ·7373 foot pound per second, and there are 746 watts in one horse-power. I am in hopes that the present horse-power will become a thing of the past, and that all engineers will measure power in watts, on the decimal system. A kilowatt is not such a euphonious name, but it is a truer and more scientific term than horse-power. An engine giving off 10 horse-power develops therefrom 7,460 watts. Now, an average glow lamp, well incandesced, gives one candle-power light for each three watts expended in it, and, therefore, a 20 candle-power lamp absorbs 60 watts, and a 10 candle-power lamp 30 watts. Hence, 10 horse-power, if all utilised in the lamps, will maintain 124 20 candle-power lamps, or 248 10 candle-power lamps in full incandescence. Thus, if we know the watts to be expended in the lamps, it is very easy to calculate the power required to maintain them alight. It is customary to allow eight 60 watt or sixteen 30 watt lamps per horse-power, so as to give a fair margin for loss in conversion and transmission.

A simple effective safe domestic steam motor has yet to be introduced. Hathorn, Davey and Co., of Leeds, exhibited at the Inventions Exhibition the best that has yet been made, but it has the disadvantage of requiring a large supply of water to condense the steam. It is a vacuum engine working at atmospheric pressure, and is, therefore, free from explosion. The various high-speed engines that have recently been introduced by Peter Brotherhood, Willans and Robinson, Fielding and Platt, Beauchamp Towers, &c., require higher technical skill than is usually to be found among the domestics of an ordinary household, and the difficulty of comprehending, examining, and repairing them stands in the way of their use. A simple single or double acting steam engine of small horse-power, that shall be economical in working and not liable to break down, easy of repair, that shall work with great regularity of speed, and be easily governed, and that does not require a skilled engineer to attend to it, is a great desideratum. The Society of Arts have under consideration a plan, so eminently successful in the agricultural world, and pursued for many years by the Royal Agricultural Society, of offering prizes for the best engines designed to fill the special purpose of providing power for electric lighting purposes. The points of merit that are considered to be of the greatest importance are—

a. Regulation of speed.
b. Power of automatically varying speed to suit variation of load.
c. Noiselessness.
d. Cheapness.

The competition is intended to embrace all classes of engines—steam, gas, petroleum, &c. The gas engine seems best adapted to supply this want. Gas is already in use in most establishments within reach of gas works, and it seems far more natural to utilise the energy stored up in gas to generate power, than to poison the atmosphere we breathe, deteriorate our valuables, and dirty our walls by burning it in air for illuminating purposes, especially as we get more light by doing so. Twenty-five cubic feet feet of gas will give us 1 horse-power, or eight 20 candle-power glow lamps, or 160 candle-power in all; but five 5ft. burners will give only 75 candles when burnt in air in ordinary burners. Gas engines are within the intelligence of butlers, gardeners, and coachmen; they are always ready for work; they attain their maximum efficiency at once; they can be stopped in a moment. They are not noiseless, though they are advertised to be so, and they are rather wayward. Some of them develop tempers of their own, and they occasionally cause angry expressions, but their efficiency is remarkable; and in spite of an oppressive monopoly nearly as bad as that of the telephone, they are rapidly coming into favour, and when the present patent expires, they will doubtless receive very great improvement, and much greater development.

In England, the opportunities of using water power are few and far between. Small powers are easily obtained, but from 10 to 15 horse-power requires a considerable quantity of water, or a higher fall than is usually attainable in any but hilly countries. The power of the tide, or that of a flowing river, is very small when utilised within the limits of ordinary people. The whole flow of the Thames through London Bridge would maintain only 800 lamps alight. In Scotland, however, the case is different. There several persons have utilised the water stored up in lakes. Sir John Fowler has lighted his highland home by using three turbines of 12 horse-power, which, night and day, work dynamos. A 5in. pipe from an artificial lake gives a head of 310ft. Many wonder why the wind is never used, but, apart from its uncertainty and unreliability, there is the fact that the power developed by the best windmills is, on the average, but very small. They are so unreliable that the proprietors of most windmills keep a steam-engine as a stand-by. The windmills so largely used in America and Holland for irrigation purposes exert but a fraction of a horse-power, and it requires a very wide expanse of sails to obtain, even in high winds, sufficient power to light a country house.

The Dynamo.—The relief which the practical world receives from the removal of the burden of a monopoly is well illustrated by the advances made in dynamos. The expiry of the Gramme patent was the signal for energy everywhere. Not only has the construction of the instrument been vastly improved mechanically, but its output has been trebled, and its price reduced to one-third; so that the dynamos of to-day are nine times better than they were during the existence of the patent. We are chiefly indebted to Elwell and Parker, of Wolverhampton, for leading the way. Hefner Alteneck first struck out a new path, which was taken up by Edison, and indeed has been well-nigh perfected by the high scientific attainments of Dr. J. Hopkinson. Science has converted a crude instrument into the most perfect converter of energy that exists. Commercial enterprise has brought it within the reach of all. I have for the past two years been converting 2 horse-power into electrical energy with an Elwell-Parker dynamo that cost £30.

The improvements that have been effected are due chiefly to the more intimate knowledge that experience and study have given us of the theory of the machine. Better shaped magnets, more intense fields, more accurate proportion of parts, better copper and better iron, improved ventilation, have trebled the energy given out by each pound of copper wound on the armature. The intensity of the field has been increased five times; machines are far less troublesome; faults have become less frequent; armatures do not burst up so often; sparking at the brushes is less evident; commutators do not cut so much; heating of the coils is a thing of the past; and the ill effects of self-induction are being eliminated. The forms of dynamos are being whittled down to two or three recognised shapes; but as long as the spirit of rivalry is stirred up by competition and emulation, so long shall we have some manufacturer who will make a change for the sake of a change, and who will advertise his wares as the best in the world. Suffice it to say, that for us users little remains to be desired in the quality and price of the dynamos. The output may be increased, and the speed may be reduced, but we cannot gild refined gold nor paint the lily.

The efficiency of a dynamo is the ratio of the energy given out in the external circuit to the energy supplied by the engine, and this in most

* Paper read at the Society of Arts, March 24 1886.

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modern dynamos exceeds 80 per cent. The output of a dynamo is measured by the number of watts it delivers, and this becomes a very convenient measure and indication of its capacity. Dynamos are now indicated in kilowatts (or "units," as some call them), and when we are told that such and such a dynamo is a 12-unit or a 12-kilowatt dynamo, we know it can deliver 120 amperes at 100 volts, or 150 amperes at 80 volts, or 200 amperes at 60 volts, according to its requirements. This also enables us at once to determine the horse-power required to drive the dynamo. Twelve kilowatts means 16 horse-power, add one-fourth to allow for loss and waste, and we get 20 horse-power. Dynamos usually indicate the E.M.F. they work at when driven at a certain speed, and they have, or ought to have, the proper number of revolutions per minute engraved or painted upon them. If makers would only supply with their dynamos their characteristic diagrams we should have all the information the user wants. Dynamo sare classified into *shunt*, *series*, or *compound* wound, according to the work they have to do. The former are almost exclusively used for domestic purposes, for reasons which will presently appear. A well-constructed dynamo, kept clean and well lubricated, and never overworked, should last a lifetime without much attention, except to the brushes and commutator.

(To be continued.)

PHYSICAL SOCIETY.—March 13th.

Prof. BALFOUR STEWART, President, in the chair.

Prof. U. S. Pickering and A. C. Hayward were elected members of the Society. The following communications were read:—"On the Growth of Filiform Silver," by Dr. J. H. GLADSTONE. It has long been known that if a piece of metallic copper be placed in a solution of nitrate of silver, replacement of one metal by the other will take place, the silver being deposited in the crystalline form, sometimes having a resemblance to fern leaves, or as superposed hexagonal plates, or knobs. It was observed, however, as far back as 1872, by the late Mr. Tribe and the author, that if nitrate of silver were decomposed by suboxide of copper instead of the metal the silver presented itself in threads, which rarely, if ever, bifurcate, but frequently turn at sharp angles or twist in every direction. This was described in the British Association report for 1872, and it was observed that the same forms occurred in native silver. More recent observations have shown that the particular character and rapidity of formation of these threads depends very much upon the strength of the solution, and the condition of the suboxide. Hydrated suboxide will scarcely decompose a two per cent. solution, even after standing. The threads, which bend at a sharp angle, usually do so at 60 deg. or 120 deg.; other threads, however, are symmetrically curved; but, especially in strong solutions, they are given to twisting about in every direction, and generally terminate in irregular knobs of silver. As a rule a thread continues to grow of the same thickness as it commenced, but it sometimes enlarges for a while into a flat plane, or becomes encrusted for some distance with small crystals of silver. When the solution is very nearly exhausted of silver, fine arborescent forms appear; but with the suboxide there are never produced the fern-leaved forms, or hexagonal plates, or the other distinctly crystalline structures which characterise the growth from metallic copper. During the reaction the suboxide is changed into black protoxide and metallic copper, which dissolves; and the change will take place as well with the acetate and sulphate as the nitrate. If a mixture of suboxide and metallic copper be employed, not only do the distinctly crystalline and the filiform forms make their appearance, but strange intermediate forms come into existence.

"Apparatus for Measuring the Electrical Resistance of Liquids." By Prof. REINOLD. The apparatus consists of two bottles connected by a horizontal tube. The whole is filled with the liquid to be examined and immersed in water, by which means and by thermometers inserted in each bottle the temperature may be regulated and accurately ascertained. The electrodes are platinum plates, one dipping into each bottle. Two fine tubes terminate near the ends of the connecting tube, and electrodes are fitted into them at some distance from the ends; by connecting these to a quadrant electrometer or a condenser and galvanometer, the difference of potential between the ends of the tube can be compared with that at the ends of a known resistance in the same circuit.

"On Chromatic Photometry." By Capt. ABNEY and Lieut.-Col. R. FESTING (this paper had been previously communicated to the Royal Society). A series of experiments had been made by the authors to determine the comparative luminous effect of different parts of the spectrum. A monochromatic light from any part of the spectrum of the electric arc was obtained by a method devised by Captain Abney, and previously described by him to the Society [Physical Society, June 27, 1885]. The photometric effect at different parts of the spectrum was compared with that due to a candle at different distances by Rumford's photometer. In using this it was found best to place the candle in a given position, and obtain a balance by moving the slide upon which the spectrum was formed, and through a slit, in which part of the light was allowed to pass, rapidly to and fro. For each portion of the candle there are thus two corresponding positions of the slit. From the results of these observations a curve may be drawn showing the luminosity at different points. From the method by which it is obtained it is evident that the curve of one observer is not directly comparable with that of another, since a deficiency of perception in any part of the spectrum would affect the light of the candle as well as that examined. Since, however, the curves obtained by a great number of persons coincide very closely with those obtained by the authors, they have felt justified in adopting them as the normal curves. In the case of the electric arc the normal curve attains a maximum rather nearer the red end of the spectrum than the blue. Assuming the normal curve, any other curve may be compared with it by increasing or decreasing its ordinates so that no part of it shall lie without the normal curve; in curves thus obtained, several of which were shown, deficiency in colour perception is often very clearly marked. By the use of two or more slits in the movable slide experiments were made upon mixtures of colours, and it was found in all cases that the luminous effects of a mixture of colours was the sum of the luminous effects of its components. It was also found that the colour of the comparison, and the quantity of light admitted to form the spectrum, were without effect upon the form of the curve. Light from the sun, and from an incandescent lamp, were similarly examined, though it should be observed that the result for sunlight differs notably from that given by Maxwell. An examination has also been made of light after passing through a turbid medium, and an expression of Lord Rayleigh's

$$I' = I e^{-x\lambda^{-4}}$$

where I is the original radiation, I′ that after passing through the medium, λ the wave length of the light, and x a constant depending upon the medium, has been closely verified.

COMPANIES' MEETINGS.

German Union Telegraph and Trust Company (Limited).

The fifteenth ordinary general meeting of the shareholders of this company was held at the offices, Winchester House, 50, Old Broad-street, on the 22nd inst., Sir James Anderson in the chair.

The SECRETARY (Mr. Wm. Payton) read the notice convening the meeting and the minutes of the last meeting, which were confirmed by the present meeting.

The report of the Directors for the year ended December 31st last, stated during that period the total receipts amounted to £10,930, which, with the balance brought forward, made a total of £11,036. The expenses for the same period amounted to £823, of which £750 was provided by the German Union Company of Berlin. The renewal fund and reserve fund of the Berlin Company now amounted to £58,000. The capital was £330,000. The cables were in good working order. The International Telegraph Conference, held in Berlin last year, had introduced reforms of great importance for European traffic. The Agreement for the reduction of tariff between Great Britain and Austria and the countries beyond, which the Berlin Company accepted, had led to a satisfactory development of the traffic, and it was hoped that their receipts, by a further increase in this traffic, would not suffer any loss.

The CHAIRMAN: Before moving the adoption of the report, I shall, as usual, make a few observations on it. You will notice that it is very short and very concise, and explains, as far as the working of the year goes, all that can or need be said. There is a diminution of the revenue, arising from the fact of the competition of the Atlantic companies and the reduction in their tariffs, compensated, however, to some extent, by the increase of traffic between Great Britain and Germany. That, perhaps, is the main point in the report. Last year I notice in looking over the the report of the meeting I referred to the Telegraph Convention then pending, and I held out hopes that we should be able to get a resolution passed, limiting the use of code language. At the Conference that matter came up on two occasions at the Tariff Committee, and on both occasions a motion was carried by a considerable majority that we should have an authorised code, using the eight languages and the dictionaries of the eight languages; but at the general conference meeting held to confirm or re-discuss the matter, the motion was lost, and I found to my regret that we were divided among ourselves—I mean the managers of the different telegraph companies in England were not unanimous by any means as to the adoption of an authorised code or the adoption of the dictionaries of the language. The Post Office and India were against it, and others whom I need not name. The main ground of their objections was that it would irritate our customers, the merchants. My own idea was and is that by giving the merchants a few years to consider and eliminate all the words which did not properly belong to the language, they would soon fall into a code that we could understand, and as to which there would be no further objection hereafter. However, that motion was lost, and we are now fixed for five years of taking things as they are; and so far as my reflection extends, it appears to me that we are going in the direction of reducing tariffs, though gradually, I hope, until we attain a point below which even the public cannot expect us to go. I have long foreseen and said this. As to code language, I do not yet see the limit of condensation of telegrams, and of the use of combinations of words in such form that no general run of operators can be expected to challenge. I am in hopes that there is a minimum below which merchants cannot or will not care to condense; but in these two directions we are inevitably going, and the merchants have five years during which to condense the length of the telegrams and to expand the meaning of the words which they can combine, making them look like regular words of the eight languages. I do not know that one need regret it, but it will be a struggle with all the telegraph companies until they have arrived at that point. Happily, I think, the use of telegraphy is growing, and must grow, and therein lies our hope, together with the extended "life" of the cables. So far as the German Union Company is concerned we are fairly well off. We have, as you observe, a growing reserve, and all those who are associated with the management of telegraph cables look at that as their sheet anchor—to have a large reserve suitable either for

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renewals or repairs, regarding it as indispensable in submarine cables, which are under the water, and subject to wear and tear such as we are not fully cognisant of, and have no means of informing ourselves of except by experience. I am happy to say that within the last few weeks we repaired a cable of the Eastern Company in the Mediterranean 18 years old, and the captain reported that it was in excellent condition except just where it had broken; but to have broken after 18 years, and to be no worse after that period is satisfactory.

Mr. WM. FORD: What was the depth?

The CHAIRMAN: It was forty-five fathoms; but that it should be good there is more wonderful than it would be if it had been in deeper water. The advantage of the position of the German Union cables is that they are in shallow water, so that no time need be contemplated in my opinion for the absolute renewal of the whole length. We may have repairs and extensive repairs, but I should say that this is as safe a property as can be devised as regards submarine cables. With these remarks, I move the following resolution:—"That the report and accounts for the year ended 31st December, 1885, submitted to this meeting be, and they are hereby received and adopted; and that a dividend of 4s. 3d. per share be declared payable this day free of income-tax, making, with the previous distribution of 5s. 9d., a total dividend for the year of 10s., or at the rate of £5 per cent. per annum."

Mr. H. G. ERICHSEN seconded the resolution.

Mr. GRIFFITH said he feared they must agree with the Chairman as to the probability of the merchants trying to cut the rates, and so diminish the Company's income to a certain extent. He was, however, glad that the Chairman was able to hold out the hope to them that from the development of traffic on the Continent they might to some extent recoup themselves. It struck him that if telegraphy was developing itself so much on the European Continent there might be room, possibly, for them to extend their operations. They were not merely the German Union Telegraph, but also a Trust Company. They knew how greatly the trust companies in England had succeeded, and he wished to suggest that if anything could be done in the same direction as regarded the European Continent, it would be a benefit to the Company. At present all their property was in one Company. He, however, hardly knew what their property was; and he asked the Chairman to tell them what were the cables of the Berlin Company, and the probability of extending telegraphy on the Continent; and also whether there was a probability of converting the Company into a Trust Company for the purposes of the Continent.

The CHAIRMAN: I will give you a map showing you where the lines are; but to reply to the questions I must go back to the history of the Company. This is a German Company. Its head-quarters are at Berlin, and we are merely agents of the Berlin Company. Prince Bismarck absolutely declined to let us make it an English Company, though all the capital was held here—that is, almost all, for the Directors held their qualification and a little more in Germany. The capital, however, was English capital, and that came to be so much recognised that an effort was made to make it an English Company. We were invited to represent this, but we failed, and we remain simply trust agents for the Berlin Company.

Mr. GRIFFITH: There is no possibility of going to law with the redoubtable Bismarck?

The CHAIRMAN: Oh, no; and besides, there are no Continental cables except Government cables. We have the right by our position to all undirected German traffic, which is of substantial value to this Company. I do not know that I need enlarge on the question, but there is nothing to take into the Trust. We are simply agents for this Berlin Company, and there are no cables on the Continent except Government cables, nor are there likely to be any.

Mr. FORD: There are no companies you could take in?

The CHAIRMAN: No, and none likely to be. Everything is in the hands of the Governments. We have not overlooked the point raised by Mr. Griffith. We have a cable now from the Anglo-American station at Valencia to Emden, and a cable across from Lowestoft to Emden. Those are all the cables we have, or are likely to have. He then put the motion, and it was carried unanimously. Continuing, he proposed the re-election of the retiring Director, Mr. John Denison Pender.

Count OSCAR VON REICHENBACH seconded the resolution, which was carried unanimously.

Mr. PENDER having briefly acknowledged his re-election,

Mr. FULLER proposed, and Mr. KENNETH ANDERSON seconded, the re-election of the auditor, Mr. Henry Dever, F.C.A., which was unanimously agreed to.

Mr. FORD then proposed a vote of thanks to the Chairman for presiding, and to that gentleman and the Directors for their conduct of the Company's affairs. It was some satisfaction to hear that, in these days of change, they would have five years' uninterrupted enjoyment of such privileges as belonged to them at the present time. Five years was almost eternity in these days, but he hoped at the expiration of that period that the days of Democracy would not have come upon them, and that there would still be some rights and privileges for property to enjoy.

Mr. GRIFFITH, in seconding the motion, referred to the great ability of the Chairman, and to the urbanity and readiness with which he gave explanations and information which might be asked for.

Mr. FORD put the resolution, which was carried unanimously.

The CHAIRMAN: I am very much obliged to you on behalf of my colleagues and myself. We do all we can to help our colleagues in Berlin, and we did what we could while we were there last year. We are very much indebted to our Managing Director there, Dr. Lasard, for the way in which he saw all the changes and reductions on the Continent, there being no reduction for us. Germany did all she could to get the companies to reduce their rates, but I do not find that she has reduced them much for herself [laughter].

The meeting then separated.

The Direct Spanish Telegraph Company (Limited).

The twenty-fifth ordinary general meeting of this Company was held at the Company's offices, Leadenhall-buildings, Leadenhall-street, E.C., on Tuesday, 23rd inst., under the presidency of Sir James Anderson.

The MANAGER (Mr. Ch. Gerhardi) read the notice convening the meeting and the minutes of the last general meeting. The report of the Directors and statement of accounts were taken as read.

The CHAIRMAN: Before moving the adoption of the report I shall make a few observations. At the last meeting I find I dealt with what we had done at the Telegraph Conference, and I referred a good deal to our failure to get the line through Spain from Bilbao to Carthagena, and I referred also to the fact that we had failed in obtaining a good direct wire from Madrid to Bilbao. This has been the object of this Company for a great number of years, and I am happy to say that it has met with the approval of the Cabinet of Spain for the first time, and thanks to the good offices and friendly disposition of our ambassadors, Sir Robert Morier and Sir Clare Ford, the Cabinet have put the matter in train, and we are now likely to get a good wire established from Madrid to Bilbao. We think that this will be of considerable advantage to us in improving the traffic, for, after all, the speed has a great deal to do with it. Next we are endeavouring to obtain an office in the Bourse at Barcelona. Our manager, Mr. Gerhardi, will go over there in a day or two to push the matter. If we had an office in the Bourse, we have many reasons for supposing that the traffic would be more reliable and would increase. Hitherto there has been a strange divulging of messages in Spain that we have been unable to trace, and unable to control, notwithstanding all sorts of efforts that we have made. I may say that the divulgence of those Bourse messages has induced the brokers to send fewer telegrams than they might otherwise have done, and we hope by getting that office we shall get more traffic. In these times of great depression, it is very gratifying to see from *The Times* of the 15th inst. that the whole of the exports of Spain in 1885 were 40 millions sterling, a figure which some years ago was assumed as the total of Spanish exports and imports. The fact is that the Spanish trade appears to be increasing. I have read somewhere that someone has come over here, or is coming over, to endeavour to bring about a *modus vivendi* with the British Government by which we shall enjoy the favoured nation clause commercially with Spain in the same way as other nations are now enjoying it. You all know that for a long time Spain has refused to give Great Britain the favoured nation clause on account of our alcoholic tariff, but I believe we have always been ready to alter that as soon as she should show a disposition to give us the same terms as she gives to Germany, France, and other countries. These are the two hopeful signs of our future. Then I referred at the last meeting to the postponement of examining the old cable between England and Bilbao. The Eastern Company were not in a position to lend us one of their smallest priced ships for that purpose, because they had unfortunately lost a ship. Now, however, the Eastern Company has two ships coming home next month, and they will be coming home with their tanks empty, and I have proposed that these two ships should go into the Bay of Biscay, and take an independent engineer, a member of the firm of Clarke, Ford, and Taylor, who shall superintend the picking up of the cable, and examine it so as to see how far it is worth raising and repairing—whether, in fact, it is worth retaining as an asset, or whether it is cheaper for us to recommend to you to condemn it and reduce our capital. The other ship will come on to Falmouth, and will be there joined by one of the assistants of Clarke, Forde, and Taylor, and they will examine the part in the Channel, and bring home the cable, and we shall see with our own eyes whether it ought to be retained as an asset, or whether the capital should be reduced. These things are being done, and I do not know anything more that could be done. In fact I am sure nothing could. We still have to regret the reduction of the length of telegrams. We do not appear to have got to the bottom which merchants are determined to arrive at in the reduction of the length of telegrams, or in the combination of certain words to mean a great deal more than we ever contemplated when codes were introduced. But we failed at the last Convention to get that protected or altered, for even though on two occasions it was passed by the tariff committee, it was rejected by the full conference, and as I have said on a recent occasion the merchants have now five years to run during which they may condense their telegrams as much as they choose, and make them as cheap as possible for themselves. But I am in hopes that with the reduced tariff that we are now coming to, and with the condensation already arrived at, we are not far off the bottom of these things which are pulling against us. I am happy to say there is a small gleam of comfort in the fact that our traffic has improved during the last quarter. We have £500 to the good as compared with the same period last year, and I do not see any reason at all why the Spanish traffic should not be double what it is now. At present the traffic is ridiculous for a country like Spain, and I do not think we are anything near its full development. I am not a pessimist, and therefore I look hopefully to the future. He concluded by formally moving the adoption of the report and accounts.

Mr. EDMUND ETLINGER seconded the motion.

A SHAREHOLDER asked what would be the cost of a new cable.

The CHAIRMAN: We paid £60,000 for the last one, and I do not suppose we could get a new one for anything less, and I do not think it would be wise to contemplate laying a new cable unless we saw our way clearly to make it pay. The new cable is represented by debentures and the old cable by the capital. If you lose the latter your assets are gone. It may be that we might find half of it worth repairing, and that a small amount would make it intact.

Mr. HUGHES wished to know whether any payment to the preference shareholders depended on the state of the old cable.

The CHAIRMAN replied that in some measure it must. They had no reserve to speak of now and their assets were not properly protected with-

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out a reserve. They could not really decide what should be done until it was settled whether they were to reduce the capital or not, which could not be carried into effect without convening a meeting of the shareholders.

Mr. COCHRANE animadverted on the fact that the Company was asked to pay income-tax when it was earning nothing. He suggested whether a committee might not be formed for the purpose of transfering the Company to the Eastern Company, and expressed his dissatisfaction with the constitution of the Board, two of the directors being also directors of the Eastern Company.

The CHAIRMAN pointed out that the Eastern Company would not buy it, for the Direct Spanish had not much to sell. In the course of the next month they would know something more about it, and it would be the duty of the Directors to call a meeting to put the whole state of the affairs before them, and consider the question of the reduction of capital. The assets of the Company never represented the capital by a long way. If the shareholders brought about any reduction in the capital he would personally only be too glad.

A SHAREHOLDER asked what would be the cost of repairing the old cable.

The CHAIRMAN said that experienced engineers were going out practically at cost price, quite independent of this Company and the Eastern Company, and it was for them to say how long the ship would continue working and picking up the cable. But if after picking 40, 50, or 100 miles, or any part of it, they came to the conclusion that it was simply whipping a dead horse to proceed with the work, they would at once stop and come home, and tell the Directors the state of affairs.

The motion was then carried.

The retiring Directors, Sir James Anderson and Mr. John Denison Pender, were afterwards re-elected, as was also the auditor, Mr. Herbert R. Duke, and a vote of thanks having been passed to the chairman the proceedings terminated.

Electrical Power Storage Company (Limited).

The adjourned fourth ordinary general meeting of the shareholders in this Company was held at the Cannon-street Hotel on the 25th inst., Sir Daniel Cooper, Bart., in the chair.

The SECRETARY (Mr. Holland Dell) read the notice convening the meeting, and the Directors' report was taken as read.

The CHAIRMAN said: Gentlemen, I consider the most convenient method of transacting the business before us will be to deal with the years 1884-1885; at the same time the discussion must include both years, and my remarks will therefore cover the same period. At the conclusion of the adjourned meeting the fifth ordinary general meeting will be held. The report deals fully with all the points of interest to the shareholders, and I now propose to make some observations upon it and the statement of accounts. You will have gathered from the report that the business of the Company has rapidly increased, a marked improvement having taken place during the latter half of 1885, and the prospects for the current year are extremely encouraging. In accordance with the Articles of Association the accounts of 1884 have been open for inspection at the offices of the Company, and the balances therefrom have been carried forward to the accounts of 1885. You are aware that a heavy loss was made in 1884, but the result of a complete change of management is that in 1885 we have made a profit upon manufacture, and are now also receiving cash remittances from the realisation of our patent interests abroad. We propose to spread the suspense account of 1884—£9,848. 19s. 10d. over the next five years, as we consider this amount was not fairly attributable to 1884, but to 1883 as well. The year 1885 shows a gross manufacturing profit of £10,902. 17s. 10d. I think you will agree with me that these figures are most satisfactory considering the adverse circumstances we have had to struggle against. We undertook to greatly reduce the expenditure; we have done so, and have at the same time secured thorough efficiency. The net result is that the profit and loss account for the year 1885 exhibits a profit of £2,200. 9s. 2d. The past two years have been a period of great anxiety to the Directors, and we have all given unremitting attention to the affairs of the Company. I would point out that we have not taken any fees, but we intend, with your approval, to take them in future. You see from the balance-sheet that when the shareholders did not come forward sufficiently to support the Company, the Directors provided the cash with which the present satisfactory position has been attained. The Millwall works are large, and amply sufficient for an increased output, and a slight strengthening of the staff, as at present organised, would suffice for this purpose. The manner in which the electrical and engineering work entrusted to the Company has been carried out by our engineer (Mr. Drake), the works manager, and the staff, has met with general approval, and a reputation for thorough workmanship has been acquired which has placed the Company in the first rank of electrical contractors. In proof of this I would mention two of the latest installations carried out in London, viz., the Bank of New South Wales and Lloyd's, as examples of the Company's work, which are readily accessible to those desirous of being convinced as to the efficiency of its installation work. A third installation, that for 1,500 lights at the Prudential Asssurance Company, is not yet completed, but will, when finished, I do not hesitate to say, stand pre-eminent for magitude and quality among the electric light installations of this or any other country. The Company is now extending the field of its operations, as, for example, the lighting of the Folkestone Exhibition, the contract for which has been given to us on satisfactory terms. As a frequent visitor and well-wisher to the town of Folkestone, I am very desirous for the success of this Exhibition, and I have no doubt that our staff will make a perfect success of the electric lighting there. We have also contracted to furnish a large number of lights, about 1,000, for the forthcoming Colonial Exhibition, in which I, of course, take a deep interest. The batteries have for some time past given every satisfaction to purchasers, and have been adopted by all the large electrical companies and firms, and by many private gentlemen for their residences. Among these may be mentioned Sir William Thomson, Sir W. Armstrong, Mr. Harben, Mr. Littleton, Mr. Fred. Green, Sir David Salomons, Lord Thurlow, and many others. The Directors have personally brought to bear what interest they possess in getting orders for the Company, and several installations have already been the result, and they ask the shareholders to assist in the same way with their friends in the lighting of private houses, banks and companies, where their influence may be of much service. In temporary lighting for balls, evening parties, &c., the company is doing good business. Among them the lighting of Marlborough House for H.R.H. the Prince of Wales, and Grosvenor House and Eaton Hall for His Grace the Duke of Westminster, may be specially mentioned. In the propulsion of boats and tramcars large progress has been made during the past year, and we may expect the progress to continue. On the Continent electrical tramcars are used, as at Berlin and Antwerp, and are having more attention than even in this country, and as regards the propulsion of boats we look for more orders for this class of work from the successful running of the Duke of Bedford's electric launch. A considerable extension of train lighting can also be expected during the current year. The London, Brighton and South Coast and the South Eastern Railways are determined to meet the wishes of the public for the electric lighting of railway carriages, and other companies have the matter under consideration. In regard to the long-continued negotiations in the United States, to which I alluded at previous meetings, it is with much satisfaction I have to announce that they have been brought to a successful issue. It gave the Directors much pleasure to welcome to England the American gentlemen who, with their electrical staff, have just returned to their own country, after a most thorough study of the methods of manufacture of batteries at Millwall and the installations erected by this Company. They are the gentlemen to whom reference is made in the report as having recently associated themselves with the New York Electrical Accumulator Company, in which we have a large interest as shareholders, and who by energy and skill in management have already achieved a brilliant success in America in another direction. Mr. Theo. N. Vail, so well known in the States in connection with the American Bell Telephone Company, has accepted the post of president of the New York Electrical Accumulator Company. The outlay in the United States has been necessarily large, but we believe that we shall be now amply repaid. Regarding the foreign business I have nothing to add to what is stated in the report. We are pushing the business and selling the batteries direct throughout the Continent. The suit in Germany relates to a lien alleged to exist against the Faure German patent before it was transferred to this Company, and this claim, therefore, affects the payment of the German royalties. I cannot avoid referring to the injury inflicted upon our business by the Electric Lighting Act of 1882, and I rejoice to see that there is hope of its amendment during the present Session of Parliament; but we must not relax our efforts for an alteration of some of its most obnoxious clauses. The Bill brought in by Lord Rayleigh in the House of Lords deserves our warmest support. We have to regret the death of our colleague, Mr. William Ladd, which occurred last autumn. I think I have now touched upon most of the points in the report, but we shall be happy to give any further information that may be desired. I may add, in conclusion, that we are really now in the meeting for 1884, but if we merely asked you to approve of this report and statement of accounts, and then pass on to 1885 matters, it would stop any discussion on those relating to 1884. We think it best to keep the whole open for discussion, and when you have finished we will ask you to pass the 1884 accounts, and then we shall have to resolve ourselves into the meeting for 1885, and ask you to do what is necessary there. The first resolution I have to put is "That the accounts of 1884 now submitted to the meeting be received and adopted."

The VICE CHAIRMAN (Mr. John Scudamore Sellon): Gentlemen, I beg to second the resolution which has been put before you by the Chairman, and in doing so it is, of course, a great pleasure to be able to say that my long since recorded conviction seems now about to be justified by the event—namely, that to this Company, if wisely directed, honestly conducted, and efficiently managed, would be assigned the foremost position of all the important undertakings connected with the electric industry. When domestic lighting was first initiated an apparently insuperable difficulty supervened, namely, the non-existence of any means by which a continuous supply of light could be insured unless the motive and generating power were in motion—that is to say, unless the engine and the dynamo were working continuously; and even under such difficult and inconvenient conditions, the disadvantages of an unsteady and flickering light, of destruction of lamps, and of accidental breakdowns, were unavoidable. It was this intolerable state of things that made the introduction of storage batteries absolutely necessary, and we all know how, in spite of enormous difficulties, it has made its way; how the scientific and practical electricians of the present time recognise that no isolated installation is complete or perfect without it. This being so, let us consider our present position. Confidence is established in our manufactures, and we all know that progress is making rapid strides in the electrical industry. The absolute necessity of the storage system is, as I have said, generally recognised. Experience has been gained fortunately during a period when but a limited amount of work could in any case be possible, and you have, as your property, intact, patents which command the whole field in this branch of industrial work, to which I think no limit can be assigned. You also have a competent managing director, who devotes his time and energy to your service. Under him you have an efficient and trustworthy staff, and I venture also to suggest that you have a Board who spare no efforts to advance and secure your interests. In these circumstances it is scarcely difficult to forecast what the future of this Company should be. If you have such conditions as good manage-

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ment, and the control of what I assert to be one of the most important factors in connection with the rising industry of the age, I think that, however high our hopes may have been raised, they will in the end be fully justified.

A SHAREHOLDER said he thought they ought to have the report of the auditors before they were asked to pass the accounts.

The MANAGING DIRECTOR (Mr. John Irving Courtenay) having read the report of the auditors, Messrs. Deloitte, Dever, and Co.,

The CHAIRMAN said they had thought it best to go on with the meeting rather than delay it a fortnight or three weeks to go over the accounts again in order to discover the item of £6. 8s. which they had not been able to trace. At their first meeting, however, that matter would be reported upon to the shareholders.

The MANAGING DIRECTOR added that the balance of £6. 8s. was discovered at the last moment. If they had not summoned the meeting they would not have held it until it had been found.

The CHAIRMAN then put the resolution, which was carried unanimously. Continuing, he said: We now resolve ourselves into the meeting for 1885, and it is a source of great pleasure to me to get rid of our previous history up to the end of 1884, but anything more unpleasant or more harassing I cannot understand. I hope in the future, if we do not have very rosy accounts, we shall have very satisfactory ones. I hope we shall show profitable accounts. I now move the adoption of the report and accounts for 1885.

The VICE-CHAIRMAN: I beg to second the adoption of the accounts for 1885.

The CHAIRMAN put the motion, which was carried. Continuing, he said: The next matter is the re-election of retiring Directors. I beg to propose the re-election of the vice-chairman (Mr. J. S. Sellon), and of Mr. J. Irving Courtenay, the managing director. In regard to Mr. Sellon I need hardly say his knowledge and experience are of great importance to us. Mr. Courtenay is now our managing director. It is not usual for a managing director to be put up for re-election, and it may be advisable at a future meeting to alter the Articles in this respect. Mr. Courtenay has resigned the directorship of another electrical company so as to give more time to the business of this Company, and we have been fortunate in securing his services for the term of three years.

Mr. NOEL (a shareholder) seconded the motion, and it was carried unanimously.

Mr. COURTENAY: I have to thank you, gentlemen, for my re-election. The latest and by no means least interesting of our testimonials has been handed to me, and as it is from a man who is so well known all over the world, and has not yet been published, I think we cannot do better than conclude the business by reading it to you. It is a testimonial as to our batteries by Sir William Thomson.

Mr. Courtenay then read the communication, which appears in another column of our present issue.

Mr. CAWSTON said that the balance from the trading account was £10,900, and that the net profit on the trading was only £2,200. Considering their expenses at Millwall, he thought the expenses at the head office of £2,500 were very large. A sum of £1,500 was also paid for miscellaneous expenses. It seemed to him that the expenses were altogether out of proportion to the profits. While, too, they had derived only £131 from royalties, they had spent £1,000 on law expenses.

The MANAGING DIRECTOR, in reply, said that Mr. Cawston's remarks were made out of order, the report and accounts having been passed by the meeting, but the Directors were glad to give the information. Mr. Cawston thought the expenses at the head offices were high, but they were a great deal lower than they had ever been before; and he had no hesitation in saying that if they went through the items in the office it would be seen that the work was done more economically than anywhere else in London. Their rent was very high, but they had managed to reduce that. If, however, they took the payments of the various officers, including the engineer and himself, and made them up, they would find that they were lower than almost any other electrical company. The engineer's salary went against the head office. Coming to the item of law expenses, patent fees, and charges, they had had a heavy lawsuit—two, in fact, one in connection with their late works manager. Then there had been the Elwell-Parker suit, which had been satisfactorily settled, and that firm now paid them royalties. Nothing, however, on that head was included in the accounts, which went up to the close of last year, and the royalties did not commence to run until about the beginning of the present year. As regarded the other law charges, if they did not think fit to defend their patents, either in this country or abroad, they might as well retire from business, because persons would not pay the price of a patented article if the owners of the patent allowed others to manufacture it without taking proceedings against them. The Directors, however, intended to proceed against those who infringed the Company's patents. The accounts were not yet credited with any royalty either from the firm of Elwell-Parker or any one in this country. The German royalty, too, was "hung up" on account of a dispute regarding the title of one of the patents; and the Court stated that the royalty could not be paid to the Company before that matter was settled. As regarded the litigation in the United States, that was now satisfactorily settled; and the American interest they had now in New York was a most valuable property. They had had a heavy expenditure in connection with these matters, but it would all come back to them, and indeed was now coming back to them. He knew it was dangerous to prophesy, but he would be very much disappointed if by the end of this year they did not receive a great deal more money from abroad than they paid out, that was to say, that the outlay for this next year would be very much less than the cash they would receive. They could not, however, expect anything if they did not defend their property, and however much they would all prefer peace, if there was a direct attempt to rob them by pirating their patents they must take action and defend their property. They had received in the past month a substantial sum from America, but it was not to their interest that he should state publicly how many shares they held in the American Company.

The CHAIRMAN said it ought to remembered, as regarded the expenses, that theirs was a young Company and a young business; and until they got to a certain point the expenses were always entirely out of proportion to the business done. They really only began business towards the commencement of last year. It was not until they had made the existing arrangements that they began to do profitable work, and the profit shown had been all made in about six months. Mr. Drake and Mr. Gorham had done what no other men in their department had done. They had worked for the Company day and night to bring the Company's accumulator into a state of perfection, and it had been brought to a state of perfection which they had scarcely ever expected it to attain. The Directors did all they could to attract business, and they were constantly at the office. They never spared themselves, and he could say the same of the officers. They had worked the thing up from a wretched into an excellent state. A good deal might be said respecting the litigation on the Continent, but they did not think it would be wise to give a foil to their opponents. When, however, they got to the end of the matter they would be able to lay before the shareholders the result. It had been the same with the American business. That seemed in a hopeless position, but all at once, by their persevering, it took a turn, and he hoped they would get something like what they originally expected. To state everything fully, however, would be prejudicial to the interests of the Company; but when matters were closed, whether they failed or succeeded, the result would be made known to the shareholders.

A resolution having been passed re-electing the auditors, a unanimous vote of thanks was accorded to Mr. Drake, Mr. Gorham, and the staff.

On the motion of Mr. CAWSTON, seconded by Mr. NOEL, a hearty vote thanks was passed to the Chairman and Directors.

The CHAIRMAN, in reply, said: On behalf of my colleagues and myself I promise that you shall have the very best of our time. It is much more cheering now, especially when we meet with approval in what we have done. I assure you that you can have no idea of the amount of time and anxiety it has given the Board of Directors to get the Company out of the false position it was in, but adversity sometimes leads to prosperity; and I think the lesson that we have had will, now that we see our way to good business, lead to prosperity. I will promise you that we will give our very best attention, and all the time we can possibly spare, to work the Company up to a state of real prosperity, and I hope we shall give satisfaction. Without boasting, we are in a position now, with the assistance of the officials whom you have been kind enough to thank, to make an installation better than any other Company in existence. Not but that there are very clever men, and men who, according to their systems and ideas, do the work extremely well; but what you require in private houses, banks, and large installations is to have a perfectly steady light, like that to which Sir William Thomson refers. Sir William Thomson, too, is not the only man who found this out. Sir William Armstrong would not think of going to any other light. Mr. Preece, of the Post Office, is also satisfied. He has it in his house. And there are several of the other leading electricians who you may say only a few months ago doubted whether we had got an accumulator, and then they thought we might have something that was rather better than any other going; but still they had no confidence in it. Now, however, every installation we make proves to these men that we have not only got a really reliable accumulator, but one that gives a light adapted to the eye, and to pictures, a light such as has never before been in existence. I am quite certain that month by month we shall attain a solid and satisfactory position, and it is the encouragement we now get from you as shareholders, and the encouragement we are getting from these leading men and the public, that cheers us on. I hope that, although the work may occupy much of our time, it will not, at all events, give us the anxiety we have had in the past, with shortness of money and everything about us unreliable and unsatisfactory. I hope my observations now will also give you some encouragement to stand by us and help yourselves and help the Company in getting into this leading position. Our engineers wish—and we encourage them—to do all the work in as perfect a manner as possible, and not to go in for a large quantity of work and do it in an indifferent manner, which would only cause a certain amount of want of confidence in us. The work we do we try to do as perfectly as possible, so that when an installation is started it goes straight, and there is no patching afterwards required. I think if we follow that course we shall work up this Company into a most satisfactory condition. If the Act of 1882 is altered—and it must be, for it is unworkable—we hope to be in a position to increase the business of the Company very largely, and we can do that without much increasing the expenses of the head office or at Millwall. In fact, the only increased expense we should have would arise from a slight strengthening of the staff. I beg to thank you for your kind votes of thanks to my colleagues and myself, and to Mr. Drake, Mr. Gorham and the staff.

The proceedings then terminated.

The Swan United Electric Light Company (Limited).

The adjourned third ordinary general meeting of this Company was held on the 23rd inst., at the Cannon-street Hotel, Mr. James Staats Forbes in the chair.

Major S. FLOOD PAGE (the secretary) having read the notice convening the meeting, the report of the Directors and the statement of accounts were taken as read.

The CHAIRMAN: I will make a very few observations upon them. I do not know whether any honourable proprietors were present at the meeting of

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the United Company, with which we are so nearly allied—the Edison and Swan Company, because what I have got to say to-day as to the results of the Swan Company, as distinguished from the Edison and Swan Company, bears a good deal of analogy to what took place at that meeting. It is very important to the Swan Company, because, as you know, as reference to the balance-sheet will show you, you are the principal shareholders in the United Company, the difference between the two things being that you have a foreign business to carry on and develop over and above the business which is to be carried on and developed in Britain. Well, now, these things are very much alike. What took place at the Edison and Swan meeting was this: We showed that both the Edison Company and the Swan Company in their initiation had made great mistakes, had paid too much for their patents, they had entered on business of which they were not masters upon terms which were very onerous, and the first duty of the united Board had been to thoroughly "bottom" the affair, make up their minds what they ought to do and what they ought not to do, and to carry on the business in future upon a sound basis. We were able to come forward at the end of the first year of the "new light," so to speak, and show the proprietors that following a particular policy, instead of landing us in a very heavy loss—£28,000, I think it was the preceding year, under the old state of things—we converted that loss into a profit of £12,000, and you remember that those accounts for the year's working showed a profit of £12,000. We did not distribute that; we carried it to the reserve. Well, now it is exactly the same story here. This account as it stands reveals—well, not a very satisfactory state of things, it reveals a considerable loss on the working of this foreign business. We have had the account made out as you see to 30th June, 1885, and you will remember that this meeting has been adjourned from time to time. It ought really to have taken place much earlier, but it was adjourned in order that we might have an opportunity, if possible, of doing abroad what we have done at home, put our horses together with our adversaries, and get rid of all the loss and cost of legal proceedings and litigation about patents. As long as litigation is pending about patents between the Edison and Swan or anybody else, the public are subject to all kinds of annoyance, and they do not see their way to enter into what may land them also into litigation. Well, our efforts have not been wholly unsuccessful; on the other hand, they have not been unattended with some encouraging results. We have two combinations of people to deal with. Mr. Edison, or Mr. Edison's friends, sold his patents, some to a German combination, having its seat in Berlin, and some to a combination in Paris, which controls France, Austria, Italy and some other countries. With respect to the Berlin business, where we were in more active competition than in any other place, we have had litigation pending now for some considerable time. Well, it is exceedingly complicated. We had there, as we had in England, the very best advice that it is possible to get. We are advised that our patents are not an infringement of the Edison patents, but that they are self-standing. Of course, the other party contend they are infringements, and that we must be "injuncted," and we are at present pretty much in the position of litigation that we are working practically with an injunction about our necks. We are told, notwithstanding all, that we shall succeed. We thought we might impress our German competitors with the wisdom of what we had done in England, because there we were competing, and we were in litigation. Fortunately litigation being pending in England, we were enabled to persuade each other that the wisest course was to amalgamate our interests on reasonable terms, and we came together, litigation stopped, the companies became much stronger united than they were when fighting against each other, and we are going on doing a very sound business in England. Well, we have taken a good deal of trouble to induce the German people to come into some sort of an arrangement, but the conditions they sought to impose—in fact, the terms—were so exceedingly unsatisfactory, that we could not accept them, and acting upon the advice of those experts whom we are obliged to rely upon in Germany—lawyers and others—we determined to wait the issue and hear the appeal which is coming on on the 27th of this month against a judgment of an inferior Court, which has so far gone against us. That Court—a Court of first instance—have delivered judgment, oddly enough, distinctly opposed to the view of the Patent Office of Germany. They were consulted as to whether this Swan invention was or was not an infringement of the Edison. Well, they are an official body, having no interest in the matter, highly skilled, technical people, even more so, I suppose, than our own Patent Office, and they pronounced a judgment distinctly in our favour. However, the Court in the first instance did not agree with the Patent Office, and they have so far said they believe we are infringers. Of course we have appealed, and the appeal will shortly be heard. You must not attach too much to it. We have most eminent patent lawyers at our backs, and we are told that we shall succeed. Well, we shall know before long. Our friends opened their mouths so wide that we did not jump down them, and that part of the business remains as it was. We fear as regards the Edison Company in Germany that it looks as if the suits must be fought out. Well, with respect to the other combination, we have had several interviews in Paris and in London; and, although I am not in a position to say that we are agreed, we are within what they call "measurable distance" of agreement—that is to say, we might think it worth our while to accept the terms which, as the result of negotiation, have been suggested to us as counter terms to our own. We do not at present feel quite inclined, and something will turn upon the result of this appeal in Germany; but there is a prospect, and I think a very good prospect, of our being able to come to an arrangement with the Paris Edison Company, controlling France, Italy, and some other countries, of an advantageous character—in fact, doing what we have done here, making a fusion of interests, and working together, not in competition, but in accord. Now, that is what I may call the political position of the matter. Another advantage of having deferred this meeting upon two occasions is that we are enabled to bring down the statement of accounts to the end of the year. Perhaps I had better just go through the report, because that will bring the matter in regular order. We have told you in the first paragraph that of the last report of the Edison and Swan Company we have said nothing in this report, because we thought it would have been fresh in the minds of the proprietors, who had a full report sent to them; but I referred to that as far as I thought it necessary in my opening remarks. With respect to the second paragraph I have told you it comments upon the position of these negotiations or litigation abroad. When we come down to paragraph 3 we deal with the substance of these accounts for the year ending 30th June, and you will see what it is. The best plan, I think, will be to go the account itself. If you look at the profit and loss account you will see what the essence of the whole matter is. You will see there that on the one side of the account the stock on the 1st of July was £4,187, and you will see the different transactions, purchase, expenses—very heavy expenses—wages and expenses of the factories, depreciation and reserve for doubtful debts, there is a total on that side of £32,484. On the opposite side you will see sales, &c., less commission and allowances, transfer fees, interest, &c., stock on 30th June, 1885, the balance being less £6,258. Well, now, at first sight that looks rather startling, and if there were not some circumstances which would make it more or less palatable, it would be very serious. It is quite serious enough as it is, but it would be very serious if it could not be explained. It so happens, however, that in that particular year our business was entirely suspended by the fire at Lille, a factory which we were called upon by the state of the French law to construct in order to manufacture and in order to maintain our patents. Another factory we had to start at Kalk, in Germany, near Cologne, precisely on the same grounds. The Lille factory had barely got to work when it was burned down, and, of course, the whole process of manufacture was stopped for a considerable time, and there we were with the rent upon our backs, the taxes, and the establishment, because with great difficulty we had got these people together. They are not to be picked up in the streets, as very few understand the process of manufacture, and we had them on our backs, although for a very long period of that year they had little or nothing to do. That is the reason the cost of production was enormously increased. Further, in order to get the customers supplied (because at this Lille factory we not only burned down our factory, but our large stock of lamps was also destroyed) we had to purchase lamps of the parent company, the Edison and Swan Company; and the Edison and Swan Company, although affiliated with the Swan Company, did not consider it their duty to hand us lamps at prime cost. We made a reasonable bargain with them, and sold a considerable number of the lamps at what to us was a considerable profit. There were two items which told against us—we had to buy lamps at a price beyond the ordinary cost of production to sell to our customers abroad, and our outturn of the balance of lamps in those factories was very greatly increased by the fire at Lille, by the fact of opening and starting a business at a new factory in Germany, where it takes a long time to get the output to a figure which is profitable. The balance-sheet, however, is not as bad as it looks, because the stock of lamps on hand on the 30th of June, put down at £7,000, is estimated at the price of production; but of course they have been produced on the assumption that they will be sold, and they will be sooner or later. You cannot carry on a business of this sort without a large stock of lamps on hand of a great many varieties—lamps of different candle-power. In fact, there are a great number of different lamps, and though you may have some thousands of lamps in hand they are divided into so many categories that the number in each category is small. It would not be polite to bring in the credit of the account the selling price of the lamps, and we bring them in at cost price as an asset, the theory being that they are worth, at any rate, what they cost to produce, the fact being that probably they will realise considerably more. But taking that as a reasonable business calculation, that £7,000 represents the saleable value of very much more, probably nearly twice as much—if that be so that balance being loss would disappear. I wish you to think that out—that of necessity when we make up our accounts we must have a large stock of lamps on hand which have been produced, which means wages, rates, and material (and material is an expensive thing in these lamps). All that has been expended and comes to the debit of the account. On the other side, we do not put in the profit in profit and loss, but merely the cost of production. Therefore, from that point of view, that account may be made, if you understand it, much more satisfactory than it seems. It would really leave us probably nearly a balance—there would be no gain, but there would be no serious loss. Dealing with the general state of things, I wish to carry you up to the assets of the Company. You see the share capital—19,750 fully-paid shares, and 79,934 shares of £5 each, with £3. 10s. each paid, less balance of instalment not due till 1st July, and calls in arrear. This account that we are now dealing with was made up to the 30th June, 1885, but presently I shall have the pleasure of telling you the result of six months later. At 30th June, however, we had got £360,000, represented by shares fully or partially paid. There is a small profit on cancelled shares, and there are sundry credit balances. On the other side there are patent rights, £104,000, awfully in excess of what ought to have been paid; but there it is. It is very easy to be wise after these periodical manias which seize the public, when they are induced to give a great deal more for patents than the patents turn out to be worth, or may turn out to be worth. Then the next items are the outlay on factories, plant, furniture, &c., less depreciation (a small item), £7,548. Then, our shares in the Edison and Swan Company—that is, the asset in the British Company that I spoke of before—£208,478. Sundry debtors were £7,634, and stock on hand £7,110. That is the stock I have been telling you about, which is brought into profit and loss account at the cost of production, and brought into the balance-sheet as an asset at that value, not at the selling price. Then there is a loan on security,

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£11,000, and cash on hand and at the bank £8,000. That is £19,000. Next comes the balance from the profit and loss account £6,258, and the loss from previous years £2,327, showing a loss on our business of £8,585 up to 30th June, 1885. Added to that you have the loss by the fire at the Lille factory £1,094. I do not know whether anyone here knows much about French insurance business, but it has been my misfortune to have something to do both as a shareholder and an insurer in a French company, and they manage in a wonderful manner to wriggle out of their obligations. We thought a considerable portion of that would be covered by insurance, which we effected through proper agents in the usual way. However, the French Insurance Company found that they could get out of it, and we were face to face with a suit, and we had to compromise the matter. We thought it better to lose a considerable amount of the sum insured rather than get into litigation with the French Company. We made up our minds that it was advisable that the Paris factory should be shut up. There was business, but there was no profit, and we thought it better to wipe off the loss there, which we did. In fact, we have been doing abroad what we did at home with so much benefit to the Edison and Swan Company. We got rid as rapidly as possible, and on the best terms possible, of bad bargains. That brings down the loss in the working of this concern to £10,800. That is not very satisfactory, but it is subject to two qualifications. One I have pointed out—that there is out of the balance-sheet and out of profit and loss account a tangible value not brought into book at all—the selling price of the lamps as distinguished from their cost price. That would go far to modify that loss. The other point is that you have paid several thousand pounds for learning the pitfalls of this business. That is another thing. One has always to pay for that; and as far as I am able to estimate this thing, from a great deal of experience (and Mr. Leyland and my colleagues will bear me out), we think it is a very good get-out of the difficulties by which we have been surrounded. In consequence of the postponement of this meeting, hoping that to-day we might have something tangible to report as to our negotiations, we have availed ourselves of the opportunity of bringing down a profit and loss account to the end of the year, and we have finished a supplemental account, going up to the 30th of September. We have increased our stock of lamps abroad at these two factories, and the dead value lying upon those lamps at this moment comes to £10,234, upon a very moderate estimate indeed. By experience we have proved that in the year we sold a very large number of lamps at the average rate of 3s. 8d. We have carried into the balance these lamps at a shadow under cost. We have taken them in at half the saleable price—rather under—at 1s. 9d. It comes to this: We hope that those lamps will be sold, and having got that stock up to a sound normal condition we shall not add to it more fully than is necessary to keep up what is called the balance of stock from half-year to half-year. I am now telling you what the factor is. It turns upon this—have we touched bottom? We have learnt a great deal. We have got the means at our fingers' ends of diminishing the cost of this output, because the greater the output the less the proportion of the cost of the lamp; and we have got a trade which we trust is growing—slowly, less rapidly than we hoped, but which will develop, we believe, with much greater rapidity once we can get rid of the litigation. There is no doubt that both in Germany and France that does stop the consumption of these lamps. People come to us and say, We want 10,000 lamps, but will you guarantee us against litigation? Will you guarantee us, as users of an alleged infringed article, that the Courts will not come and persecute us or send in their instruments to take away and destroy the lamps (because that is what they do in Germany)? We say no, we cannot undertake such business. If you like to take the lamps subject to legal risks, you can. We are both sufferers from that state of things. Many persons in Germany will not buy Edison lamps because they know the Swan interest is suing the Edison Company, and many will not buy Swan lamps because they knew the Edison Company are suing the Swan Company. Well, one does not like to get into the habit of predicting things, but one is bound to have the courage of one's opinion, and particularly with shareholders who cannot have the same means of forming a judgment as we have. Our opinion is that this thing is now as bad as it can be, but that we have got in hand an asset quite sufficient to wipe down the loss on the business up to this moment, and that the probabilities are strongly in favour of our being able to go on and turn a present loss into a future profit, and that very rapidly. That is prediction, and you must take it for what it is worth. My colleagues will all agree in that view. We give it to you perfectly *bonâ fide*. We ourselves are very largely interested in the success of this thing, and, therefore, both our pockets and our reputation are concerned; because we feel that we have been very much trusted by the proprietors in these companies, and it is our duty on that ground alone, without the other incentive, to get our money back, that makes us go into this thing very deeply, and makes us present to you our views, in a perfectly straightforward way, in this manner. Paragraph 5 in our report says:—"Heretofore the accounts have been made up to 30th June in each year; the Directors propose that the financial year shall in future end on 30th September, and for that reason they now present the accounts to the shareholders for fifteen months." We have given a supplemental account. The reason of this proposed change is, as I said before, that you are enormously interested in the Edison and Swan Company, and that company will make up their accounts to the 30th of June, and they, I suppose, will hold their meeting between the 30th June and the 30th September. And who knows—they might have a dividend to declare. If they had a dividend to declare you would stand in for a very large percentage of it, because you are much the largest holders in that Company—to the extent of £280,000. Well, we could not state our position without bringing into the credit of our accounts for the current year the results of the working of the British Company, in which we have so large a stake. We have therefore thought it better that our accounts should be made up to the 30th September, as the result will affect our common purse. In paragraph 6 we refer to the question of the distribution to the shareholders of the shares allocated to this Company in the Edison and Swan Company. We are very anxious to be relieved of the enormous responsibility of holding these shares in trust, but there are great difficulties about distributing them at present. We could not distribute them at once without involving ourselves in a question of considerable gravity, and you must again be good enough to rely on the judgment of the Board and their solicitors, that it is much better to let the matter stand where it is at present. The two retiring directors are Mr. Swan and Mr. Stearn, as to whom there will be a resolution. With what I have now said, subject to answering any questions, I now move the adoption of the report and accounts.

The DEPUTY CHAIRMAN (Mr. F. R. Leyland), in seconding the motion, alluded to the changes made at the Board at the last general meeting, when he was one of the two new Directors who were appointed, and to the measures which were subsequently taken for placing the affairs of the Company in a more satisfactory position. He also referred—following the Chairman—to the exceptional causes which had led to the loss shown on the working of the year to June, 1885, and to the other items which had gone to increase that loss. From that period he considered that they had started fair, and the accounts for the next quarter, up to September, 1885, had been made up, and showed a very satisfactory profit—a profit on that one quarter of £3,206. Nor was that to be taken as an exceptional profit, for the accounts had also been made up—though they were not passed or audited—for another three months, and they had found that the result was rather more profitable than had been the case in the September quarter. There was no doubt that the business was a profitable one; but it was quite clear that the whole thing depended upon the result of the litigation referred to, and whether they could hold their patents. Speaking of the distribution of the shares of the Edison and Swan Company among the shareholders, he pointed out that it was impossible to take that proceeding so long as litigation was pending, and that there was the question to be considered, prior to the distribution taking place, of the position occupied by those who held fully paid and those who held partly paid shares.

After a few remarks from Mr. FOSTER, and a reply from

The CHAIRMAN, who explained again how the profit of the September quarter had been arrived at, the motion was unanimously adopted.

Resolutions were afterwards passed re-electing the retiring Directors, Messrs. J. W. Swan and C. H. Stearn, and the auditors, Messrs. Quilter, Ball, and Co.; and a vote of thanks to the Chairman brought the proceedings to a close.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. March 24.		Business Done Week Ending March 24. Highest.	Lowest.
Anglo-American	36½,	37½	37⅝	35¾
Do. Preferred	60,	61	61½	59½
Do. Deferred	12½,	13½	13⅜	12¼
Brazilian Submarine	11⅜,	11⅝	11 9-16	11 5-16
Cuba	10½,	11	10¾	—
Do. Preference	17½,	18½	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	11½	12	11½	—
Direct United States Cable	10⅜,	10⅝	10⅜	9¾
Eastern Telegraph	12,	12¼	12 3-16	11 15-16
Do. 6 per Cent. Preference	14⅜,	14⅞	14¾	14
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	13⅜,	13⅝	13¼	13 1-16
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust	7,	7¼	7 3-16	7
Do. Preference	13½,	13¾	13 11-16	13½
Great Northern	14⅜,	15	15⅛	14⅞
Indo-European	36,	37	33½	—
Reuter's	6¾,	7¼	—	—
Submarine	200,	210	—	—
West India and Panama	¾,	1	15-16	—
Do. 1st Preference	9¼,	9¾	9½	9 5-16
Western Brazilian	7¼,	7½	7⅝	7 5-16
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	101	—

TELEPHONES.

Consolid. Telepho e and Maintenance	15-16,	1 1-16	—	—
Oriental	¼,	⅜	—	—
United Telephone	12½,	13	12¾	12 9-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3,	3½	3½	3½
Do. (fully paid)	,	5½	5⅜	—
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1¼,	1½	—	—
Maxim-Weston	5-16,	7-16	—	—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37½	36½ x.d.
India Rubber, Gutta Percha, and Telegraph Works	23	24	23½	23 1-16

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NOTES.

BRITISH GUIANA.—The cable between Trinidad and Demerara is interrupted.

PARA.—Telegraphic communication with Para is suspended, the cable between Maranham and that place being interrupted.

BURMAH.—Advices from Rangoon state that the construction of a telegraph line to Yemethen will be commenced immediately.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 26th March amounted to £2,544.

ELECTRIC LIGHTING BILLS.—The amendment Bills of Lord Rayleigh and Lord Bury, as well as the Government Bill, have been referred to a Select Committee.

THE RIOTS IN BELGIUM.—Considerable injury has been inflicted on the telephone system in the disturbed districts of Belgium by the workmen on strike, who have wantonly cut the wires.

PERSONAL.—We are informed that Mr. J. S. Raworth, formerly agent to Messrs. Siemens Brothers and Co., has been appointed superintending engineer to the Anglo-American Brush Electric Light Corporation.

THE RECENT GALES.—Much damage has been done to telegraph and telephone wires by the boisterous winds during the present week, especially to over housetop wires in the towns of Lancashire and Yorkshire.

THE BROOKLYN ELECTRIC COMPANY.—This company has been incorporated for the sale of electricity, lamps, and electrical apparatus generally. Its capital stock is £10,000, consisting of £500 shares of £20 each.

THE ELECTRIC LIGHT AT MODANE.—This small Alpine town of only 2,400 inhabitants has followed the example set last year by the equally small town, La Roche-sur-Forva, and has now its streets lighted by electricity.

SOCIETY OF TELEGRAPH-ENGINEERS.—The next meeting will be held at the Institution of Civil Engineers on Thursday, 8th inst., when the discussion on "Electric Lighting by Means of Low Resistance Glow Lamps" will be continued.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 26th March were £2,099, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

TELEGRAMS FOR CHILI.—From the 1st April the rate for telegrams to all places in Chili, by the routes of the Anglo-American, Direct United States, Paris and New York, Western Union, and Commercial Cable Companies, will be 10s. 4d. per word.

TELEGRAPHIC ACCOMMODATION.—Mr. A. G. Ing, who, on behalf of the inhabitants of Manor Park recently forwarded a memorial to the General Post Office, asking for the establishment of a telegraph office at Manor Park, has received a letter stating that application has been made to the Lords Commissioners of the Treasury for authority to carry out a telegraphic extension to Manor Park, and upon this being obtained the work will be put in hand.

GLOBE TELEGRAPH AND TRUST COMPANY.—The directors at the board meeting held on 30th March declared the payment of an interim dividend on and after the 19th inst. of 3s. per share on the Preference shares, less income tax, and of 1s. 6d. per share on the Ordinary shares—the income tax having already been deducted—for the quarter ending the 18th inst. The transfer books were ordered to be closed from the 12th to the 19th inst., both days inclusive.

ELECTRIC RAILWAY BRAKES.—The *Bulletin International de l'Electricité* calls attention to the recent experiments of M. Regray, on the Eastern Railway of France, which proved the great power of electric brakes. In fact, the fault to be found with these, notably with Achard's brake, is that they act too suddenly. Our contemporary thinks that the late accident at Monte Carlo might have been, if not entirely avoided, at any rate greatly mitigated, if the trains had been fitted with electric brakes.

MAST LIGHTING IN AMERICA.—The new Chamber of Commerce in Chicago has the distinction of being directly under the rays of a cluster of arc lamps which for brilliancy and height are remarkable, even in the United States. On a tower of 330ft. in height is placed a mast, carrying at the top four arms, each 14ft. long, arranged in the shape of a cross. From the ends of these arms is suspended an iron corona, 30ft. diameter, and from this are suspended twenty 2,000 candle-power lamps. Corona and lamps are let down for trimming in the usual way. It is said that the light is visible to a distance of 60 miles.

COLONIAL AND INDIAN EXHIBITION.—Her Majesty the Queen has been graciously pleased to intimate her intention of opening the Colonial and Indian Exhibition, on Tuesday, May 4th. H.R.H. the Prince of Wales, Executive President of the Royal Commission, accompanied by H.R.H. the Duke of Connaught, a Royal Commissioner, visited the various sections of the Exhibition on Monday morning. Sir Dighton Probyn, Colonel Ellis, Mr. Francis Knollys, and the Hon. Major Egerton were in attendance. Sir Philip Cunliffe-Owen, the Secretary to the Royal Commission, received their Royal Highnesses, and conducted them over the buildings.

LINCOLN'S INN INSTALLATION.—The lighting of Lincoln's Inn hall, library, and council rooms was carried out last autumn by Messrs. Clarke, Chapman, Parsons and Co., of Gateshead-on Tyne. The installation consists of about 220 Swan lamps of 20 candle-power, receiving current direct from one of Parsons' turbine electric generators governed by an electrical control-governor of great accuracy. The absolute steadiness and perfection of the light was much admired by the distinguished company present at the annual dinner of the Institution of Civil Engineers last week, under the presidency of Sir F. Bramwell, His Royal Highness the Prince of Wales being one of the guests.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA COMPANY. We are informed that the accounts of this company to the 31st December last show, subject to audit, a balance of profit of £164,188 after payment of three interim dividends, and a bonus of 2s. per share for the first half year, and charging £55,062 against revenue during the year on account of cable renewals, &c. The directors now propose to pay on the 15th inst. the usual dividend of 2s. 6d. per share, together with a bonus of 2s. per share (both free of income-tax), making, with previous distributions, a total payment of 7 per cent. for the year 1885. The balance of £41,625 has been carried to the reserve fund, which now stands at £567,802.

THE ELECTRIC LIGHT IN THE CAPITOL AT WASHINGTON. The *Electrical World* reports that the Edison lights in the

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Capitol at Washington are giving great satisfaction. The chandelier recently placed in the Senate marble rooms, substituting the Edison lamps for gas jets, was lighted on March 6th for the first time. There are twenty-four burners encased in varied coloured glass representing tulips. The design of the chandelier is a massive basket of flowers and ferns. The Edison light is now exclusively used in the Senate wing, even the elevator being illuminated by an incandescent lamp. In the cloak rooms of the house and in the library under the gallery these lights are now being used with pleasure to all.

The Electric Light in Mexico.—The *Boston Herald* gave recently an interesting account of artificial lighting in the City of Mexico. It appears that gas which is made from resin costs 24s. per 1,000 feet, and is very inferior in illuminating power to gas made from coal. At present there are 60 Brush lights in use, but the corporation are about to contract for a large extension of electric lighting. There will be 10 towers, each carrying four 4,000-candle lamps, and in addition there will be two hundred 2,000-candle arc lamps distributed throughout the city. The Brush and the Thomson-Houston Company are competing for this work. Since fuel of any kind is very dear in Mexico, the question of efficiency of dynamos and lamps is of the greatest importance.

House Lighting by Primary Batteries.—M. P. Juppont, in a little book entitled *L'Eclairage Electrique dans les Appartements*, sums up this subject in the following words :—"Lighting by primary batteries is only applicable on a small scale. Since its cost is too great, as compared to other methods of lighting, it will only be undertaken by amateurs who can fit up their own lights, and find a pleasure in watching the batteries and keeping them in order. Outside of such and other cases where the light is used as a luxury, there is no general application for batteries as regards lighting. It may be that the problem of economical lighting by primary batteries will be solved by an ingenious inventor shortly, but it may also be that we shall have to wait for this many years. Meanwhile, the incandescent lamp fed from a primary battery is simply an article of luxury."

Abbreviated Addresses.—In reply to Mr. Labouchere, in the House of Commons, last Friday, Mr. H. Fowler said :—"It is found that the fee now charged for registering telegraph abbreviated addresses does not cover the cost to the department and the loss of revenue by the curtailment of the address. At the same time the use of abbreviated addresses leads not only to delay in the delivery of messages with abbreviated addresses, but also necessarily causes delay in the delivery of messages containing a full address. The use of abbreviated addresses is detrimental to the general public, interferes with the regular working of the telegraph service, and increases its cost. Since the introduction of the sixpenny tariff, the practice of registering addresses has so enormously increased, and the departmental difficulties which have arisen have been so great, that it is a question with the Postmaster-General whether, after a certain date, it would not be well to abolish the use of abbreviated addresses, at all events for inland messages, and he cannot, therefore, lessen the present charge."

Lighting at Madrid.—The Madrid Gas Company and the consumers of gas for lighting purposes are just now engaged in a contention upon the question of the quality and price of gas, which, according to the latest Spanish advices, appears to be arriving at an acute stage. A committee has been appointed by the consumers, many of whom have announced their intention to abstain entirely from using gas should the committee, in the event of not finding their representations successful, recommend such a course. Meantime the dispute has been taken up by the Madrid Mercantile Club, a body representing a great majority of the Madrid merchants, and standing somewhat in the position of our Chamber of Commerce, though its action is generally confined to the discussion of local matters. Its official organ in the Press, *El Camercio Espanol*, in its issue of March 27, contains an invitation in the name of the trade and industry of Madrid for lighting the city by any process, either native or foreign, which will supply a cheaper and more efficient light than that of coal gas. Applicants are requested to forward all particulars as early as possible to the Madrid Mercantile Club.

Telegraph Revenue.—From the Revenue Returns published yesterday for the financial year ended 31st March, we give the following particulars relating to the telegraphs :—The gross revenue for the undermentioned periods in 1884-5 and 1885-6, was

1884.			1885.	
June 30	£440,000	....	June 30	£445,000
Sept. 30	485,000	....	Sept. 30	490,000
Dec. 31	430,000	....	Dec. 31	410,000
1885.			1886.	
Mar. 31	405,000	....	Mar. 31	395,000
	£1,760,000			£1,740,000

These figures show a decrease of £20,000 on the gross receipts for the whole year, compared with the year preceding, but are exactly that amount in excess of what it was estimated they would yield. The gross falling off in the last two quarters, during which period the sixpenny tariff has been in operation, was £20,000 and £10,000 respectively, making a total decrease of £30,000 for the half year. Against this is set the increase of £5,000 for each of the first two quarters, making the gross decrease for the whole year £20,000 as compared with 1884-5.

Patents in Germany.—A recently issued number of the German *Patentblatt* contains some interesting statistics as to the number of patents taken out in 1884, 1885, and during the period from 1877 till 1885. The figures are as follow :—

	1884.	1885.	'77 to '85.
Applications for patents	8,607 ...	9,408 ...	63,585
Applications published.........	4,632 ...	4,456 ...	38,886
Refused after publication ...	357 ...	358 ...	2,494
Patents granted	4,459 ...	4,018 ...	34,561
Withdrawn patents	18 ...	25 ...	163
Expired patents	3,984 ...	3,947 ...	23,365
Patents in force at end of year.	10,994 ...	11,046 ...	11,046

Of purely electrical patents there were :—

Applications	292 ...	387 ...	1,996
Patents granted	256	156 ...	1,086
Expired patents	— ...	— ...	621

On an average there are 54·41 per cent. of the applications granted, and for every 100 patents granted 57·18 patents expire. The small number of patents refused after publication shows that the German examiners do their work very rigorously, not accepting for publication any patents but those which can reasonably be supposed to be good, and therefore not easily upset by opposition after publication, and before the patent is finally granted.

Lighting Flour Mills.—We are informed that the Maxim-Weston Company have just completed the lighting of the extensive new flour mills at Newcastle the property of Messrs. Robert Hedley and Co. The following is their account of the installation :—"Our lights are all 20 candle-power lights, which are suspended from the joists some 10in. or 15in., and usually are so placed in clear positions as to light a space

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equal to 15ft. by 15ft. On the roller floor the lamps are numerous, a good light being required in this department, and are placed in a line as far as possible and between the different lines of roller mills, thus securing a full diffusion of the light. The distance apart varies from 10ft. to 16ft., according to the placing of the machine. On the centrifugal and reel floors they are placed between every two machines, admission being thus obtained from one side or the other to all machines, whilst portable hand lamps supplied to us by your company, according to specification, enable an examination to be made into the interior of any machine with safety. In warehouses one 20 candle-power lamp to a space of 15ft. by 30ft. will be found sufficient. Generally, the light keeps the interior of the mill cool. We adopted the light after a careful calculation of comparative cost of gas and electricity."

The Electric Light at the Law Courts.—Our daily contemporaries have—as is usual with scientific matters—very much bemuddled what, after all, is but a simple matter. A few days ago one or two of the incandescent lamps fell to the ground, or rather one of them fell upon a gentleman in the Vice-Chancellor's court. Sir James Bacon thereupon sent for the electric light engineer, and required explanations. It seems that the evil arose from a screw in the fittings being rather small, and the expansion of the materials surrounding the screw caused the threads to lose their hold and the screw to draw. The daily papers imagine that a screw passes through the top of the glass, but of course all electricians know that this is incorrect, though the general public may not be so well informed. We cannot agree with the Vice-Chancellor that the engineer was to blame, for we should imagine that this matter would be altogether out of his jurisdiction. It may be as well to inform our political contemporaries that the only metal which contracts and expands in a somewhat similar manner to glass is platinum, and that this metal is far too expensive to be formed into ordinary screws. We should advise a little more scrutiny into the scientific aspect of the case before rashly commenting upon a subject evidently outside their range of understanding.

City and Guilds of London Institute.—The sixth annual meeting of the governors of this institution was held on Wednesday afternoon, at the Mercers' Hall, Cheapside, the Earl of Selborne presiding. Lord Selborne, in moving the adoption of the annual report, read a letter from the Lord Mayor regretting his inability to be present at the meeting, and remarked that the institution had now reached the most critical stage of its history. The buildings of the central institution were completed, and every branch of the institution was practically for the first time in full working order. There was great difficulty in connection with trade both in this country and on the Continent, and that should stimulate them to make the wisest and best possible use of every possible means of improving the condition of the workmen. During the past year examinations had been conducted in 167 centres, and 3,968 candidates presented themselves for examination in 42 subjects, of which 2,168 passed. Their average yearly income was £24,000, and, if the work was to be properly carried on, at least £30,000 would have to be raised. Sir Frederick Bramwell seconded the adoption of the report, which was ultimately agreed to. It was also decided, on the motion of Sir Sydney Waterlow, to empower the council to borrow on mortgage a sum not exceeding £25,000 for the extension of the Finsbury Technical College.

The Municipal Authorities in Vienna and General Supply of Electricity.—It seems that the monopoly enjoyed in Vienna by the Imperial and Continental Gas Association, as far as lighting by gas is concerned, has induced some members of the municipal council in that city to view with suspicion the action taken by the Association with reference to the erection of a central electric light station. They fear that the general supply of electricity may thus become as much a monopoly as the supply of gas already is, and that the money which the consumers will have to spend for the luxury of having the electric light laid on will thus flow out of the country and into the exchequer of a foreign company. To prevent this the councillors would prefer that the town should erect its own central electric stations and supply its own wants. This view has been endorsed by the whole of the municipal council, who on the 3rd of November last passed a resolution agreeing in principle that central stations for the public supply of electricity are to be erected and managed by the town authorities. Other resolutions were also passed instructing the local board to report whether certain buildings and sites could be employed for this purpose, and also whether the water-power of the Danube could be utilised. It is expected that Parliament will be asked to sanction a public loan of £50,000 to £60,000 for the purpose of erecting central electric stations and other necessary works.

Telephone at Bournemouth.—On Friday afternoon last week a large number of influential residents of Bournemouth assembled at the local head-quarters (1, Adelaide-terrace) of the Western Counties and South Wales Telephone Company, the object of the gathering being to open the newly-established Telephone Exchange. Amongst those present were Captain Hartley, Mr. Fisher, Mr. C. C. Creeke, Mr. E.W. Rebbeck, Mr. W. Scott Evans, Mr. C. A. D. George, Mr. J. R. Ridley, and Mr. R. W. Sworn, members of the Bournemouth Improvement Commission; Mr. Jas. Druitt, jun., clerk to the commissioners; Mr. G. R. Andrews, town surveyor; Mr. H. A. Garrett, assistant surveyor; Dr. J. Roberts Thomson; Messrs. Bacon, Primavesi, Hankinson, Lane, Laidlaw, F. Wareham, Dunn, Hervey, Redfearn, Carr Gibbs, Dale, H. Nash, N. S. Jenkins, Nethercote, J. Worth, E. Worth, Bicker, Pyle, Helyer, J. J. Allen and others. Mr. H. F. Lewis, general manager and secretary to the company, said it was only five months since he came first [to Bournemouth with the view of opening a telephone exchange. He had an interview with Mr. Newlyn, who received them cordially; and he had to thank also the commissioners for their consideration and courtesy. They were also indebted to the inhabitants generally and to those gentlemen especially who had assisted them by becoming subscribers. All he could say was that the company on their part would do their best to deserve the confidence reposed in them. They had at the present time 41 exchange orders, and five private line orders. Nine of them had been connected, and five would be in speaking that day. The lines which were not yet connected would be pushed forward as rapidly as possible. Mr. J. Druitt (in the absence of the Chairman of the Commissioners) then opened the exchange.

Conductivity of Mixtures of Organic Compounds.—M. Bartoli has noticed, says the *Journal* of the Chemical Society, that although generally the electric conductivity of carbon compounds diminishes almost to zero at or about their points of solidification, yet certain mixtures and solutions of these compounds show an increase of conductivity at temperatures below that of the solidifying point, and a subsequent decrease to zero at a lower temperature. This phenomenon is not noticable in mixtures of natural origin, such as the oils, wax, balsams and resins, but only in artificially prepared mixtures and

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solutions, such as napthalene with one of its derivitives, napthalene or paraffin with phenol, phthalic or benzoic anhydride, and the acids of the acetic series. In this paper tables are given illustrating this phenomenon. As regards its explanation there are two possible cases to be considered—first, that of a mechanical mixture, such as paraffin in annyl alcohol (or acetic acid); second, that of the mutual solution of the two components, such as naphthalene in one of its derivitives. In the former case the interdiffused liquid would have a constant conductivity independent of the temperature up to the point of its own solidification. A simple case of the latter is the solution of a small quantity of a conductor in an insulator; such a material shows two points of solidification, the one near to that of the more abundant constituent, the other immediately below. Between these two points there is a sufficient amount of conducting liquid interposed between the solid particles to admit of the passage of the current; but this gradually diminishes with decrease of temperature. This explanation is not, however, valid for compounds such as phenol and benzamide, which possess a certain amount of conductivity at temperatures far below that of their solidification.

EARTH CURRENT STORM.—A very wide-spread earth current storm has been felt upon our various telegraphic lines. The following references show the experiences with the storm eastwards. We should be glad if some of our readers can supplement the information by giving us references westward:—

London... First observed at 8:20 a.m. on the 30th March, and terminated at 11:15 a.m., stopping work for some time.

India ... Earth current storm lasted from 2 to 5 p.m. 30th March, Indian time; strongest in the Bombay Presidency, and stopped working between Bombay and Madras.

Madras... Strength of current on Madras-Penang cable = 1 milliampere; but unable to get exact reading owing to rapid changes of polarity.

Singapore. Strong earth currents on Java cables from 3 p.m. on 30th March. Unable to work on Penang cable up to 7. About 10 became fainter on all lines, and disappeared at 7 a.m. on 31st March.

Zante .... Strong earth currents all day on 30th on Corfu, Otranto, Trieste, and Candia cables.

Gibraltar.. Strong earth currents on Lisbon and Villa Real cables, morning of 31st March.

Madras... Earth current disturbances again observed on Indian land lines at 5 a m. on the 31st March, lasting half an hour.

London... Earth currents were again observed in London on 31st March, during the morning.

Curiously, no earth current disturbances have been observed in Egypt. The cables have throughout been less affected than the land lines, owing to the use of condensers.

TELEPHONE EXPERIMENTS.—Some interesting experiments, says the *Newcastle Daily Journal*, were carried out at the offices of the Northern District Telephone Company, Sunderland, a few evenings ago. Two different types of instrument were used, one of which is known as the "loud-speaking telephone," and the other as the Blake Transmitter and Bell Telephone Combination, the latter being the instruments supplied by the Northern District Company. The experiments amply demonstrated the superiority of the latter instruments over the "loud-speaking" ones, as conversations were carried on with much greater ease, and songs and recitations were heard more distinctly than was the case with the "loud-speakers." The telephone can hardly be termed a new invention, and yet, though it is becoming very generally adopted, not only for commercial purposes, but also for domestic uses, there is still a large portion of the community who have not even seen this scientific marvel of the age. As an instance of the variety of ways in which the telephone can be employed, it may be mentioned that a gentleman in one of the rooms was singing a song, whilst the party referred to were listening in another part of the building, and at the same time the manager of the company was listening at his own residence, about a mile away. The song was unfortunately pitched in too high a key, and the executant did what many other more ambitious performers have done, viz., broke down. Successive efforts to select a key which would bring the range of the song within his compass having failed, the manager of the company struck the proper note on his piano, and the song proceeded without further mishap. We are given to understand that this company are making very rapid progress in this district, and that the Tyne and Wear will shortly be in speaking communication with Durham, Darlington, the Hartlepools, Stockton, and Middlesborough.

HER MAJESTY'S NAVY.—Messrs. R. E. Crompton and Co. have been entrusted with the order for wiring the two new gunboats now being rapidly completed at the Devonport Dockyard—viz., Her Majesty's ships "Landrail" and "Curlew." The work was given to Messrs. Crompton on their undertaking to complete one boat—the "Curlew"—in six weeks. As each ship is only to be fitted with about 85 incandescent lamps and search lights, this would appear an easy matter to any one not well acquainted with the difficulties involved. The contract, as is now usual with such work for the Admiralty, includes supplying, fixing, and fitting all teak casings for the wire leads, and drilling all holes, piercing decks, &c., also fixing all fittings, switches, cut-outs, &c. It is, of course, well known that on all war ships of recent design space of any sort is of the utmost importance; but such a generalisation as this conveys an utterly inadequate impression to the minds of the uninitiated as to the difficulties to be overcome by the electrical contractor in such cases as the "Landrail' and "Curlew." It is no exaggeration to say that every available space is already occupied either with steam pipes, water pipes, ventilating pipes, speaking tubes, gun firing circuits, bells, signals, and gear of every description, and owing to the existing fittings and the rigorous rules as to piercing water-tight bulkheads, it is frequently necessary in order to carry the wires through a space sometimes not exceeding a few inches, to turn them upwards through one or more decks, sometimes of steel, until a suitable place is found, and then descending, sometimes through the same decks, the wires are at last placed in the necessary position and an uninterrupted run of a foot or two may be gained before the next difficulty has to be overcome. When it is further borne in mind that in the majority of positions in which the wires are fixed it is quite impossible for even a small man to stand upright, and that in some specially cramped places even sitting down between decks is a tight fit, it may fairly be concluded that the contractors have no easy task to perform, and that the electrical engineer's lot under these conditions is none too happy; indeed, were it not for the able assistance and advice generally given by the courtesy of the dockyard officials, under all circumstances it would be next to impossible for contractors to take up such work.

ELECTRIC LIGHT WORK.—Messrs. Allsop and Co., stockbrokers, in their circular, say:—"The report of the directors of the Brush Company is altogether satisfactory, and the speech of the chairman at the meeting dwelt very hopefully on their future prospects. Although the action of the Electric Lighting Act of 1882 has hitherto rendered impossible all large enterprises, it is important to note that what may

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be termed the minor or retail work of this company has constantly increased, and now suffices alone to earn a dividend. This is not only satisfactory in itself, but still more as giving proof of the growing demand for electric light, and an unmistakable indication of the development which may be expected when the removal of legislative restriction shall set free the energies of this company for the valuable and profitable work of public lighting on a large scale. Slow as has been the growth hitherto of electric lighting in England, as compared with that of the United States and European countries, it is impossible to resist the conviction that its progress henceforward is now not only assured, but will in future be very greatly accelerated. Not only for lighting, but for other purposes, there is a greatly increasing demand for electric generators; notably for the propulsion of tramcars and light railway trains. This, at present, quite new industry is destined to have a great extension in the near future, and under the present able and prudent management, the Brush Company will be in a position to avail to the utmost of the impending demand. In point of fact, it has already in view some very extensive work, both for lighting and power. Without desiring to in any way overestimate the future, we may point out that great possibilities always attach to a new and growing industry, and are the reward of the few who early recognise coming developments. It is under this aspect that the position and prospects of the Anglo-American Brush Electric Light Corporation merit the attention and inquiry of those who may be seeking an investment which, while paying a moderate present dividend, contains latent promise of *exceptional* future development." We are not sure that a caution should be given to wait events rather than to be too sanguine. We certainly should like to see "more work" and "more light," and the good time is coming, even if it come slowly.

THE CENTRAL ELECTRIC LIGHT STATION IN DIJON.—The total number of glow lamps at present distributed throughout the town of Dijon and supplied with current from the central station is, according to our contemporary, the *Bulletin International de l'Electricité*, 350. In addition to these there are a very few Pieper arc lamps fed from the same mains. The station was originally designed to receive five 300-light Edison machines, and it was even contemplated at a future date, if the demand for current should have sufficiently increased, to change these dynamos for 500-light machines. But it is evident that the expectations of the promotors have as yet been very imperfectly realised. There are at present only three 300 light machines installed, and that is more than required to feed the 350 lamps which are distributed amongst forty subscribers. These machines are driven by belting from Corliss engines, and the boilers are of the Naeyer type. The mains are naked copper cables carried overhead. It is difficult to understand why the company should not have a far greater number of customers. They have plenty of spare generating power, and are entirely free from the difficulties and risks which have hitherto been almost inseparable attributes of underground distribution. To connect a new customer's house circuit to their mains must be extremely easy, and the work of a few hours. Yet new customers are slow in coming. The reason might perhaps be that the price charged for the light is high, and the manner of charging objectionable. It appears that customers have to pay according to the number of lamps fixed, whether they use them or not. The prices charged are £3. 4s. per annum for each 16-candle lamp, £2. 12s. for each 10-candle lamp, and £2 for each 8-candle lamp. Now, in private installations 1,000 hours per annum is probably the outside limit of the time during which each lamp is in use; and on this basis the electric light would be about two and a half times as expensive as gas light if gas costs 5s. per 1,000ft. To enable their customers to fix a large number of lamps without having to pay for lamps which might be only in use on exceptional occasions, the Dijon Company agree to a number of lamps being put on the same branch wire; and in charging they count, not the number of lamps, but the number of branches by which the house mains are tapped. A suitable switch is placed on each branch, by which any one of the lamps connected with that branch can be lighted; but not more than one lamp can be supplied with current at the same time. This is a device for making the system of charging simply by the number of lamps in use somewhat more palatable to the customer; but we should prefer the use of meters both in the interest of the company and of its customers.

ELECTRIC LIGHT AND POWER LEGISLATION IN FRANCE.—Our neighbours across the Channel, grown wise by watching the disastrous effect of our own Electric Lighting Act of 1882, seem determined not to submit to similar legislation in their own country. With us the key note to legislation was the prevention of a new monopoly; with them it seems to be safety of life and property. Whatever be the object of legislation with regard to electrical industries in France, it seems that the *Syndicat des Industries Electriques* views all attempts at officious interference with suspicion. Such, at least, is our impression gleaned from a very interesting address which M. P. Lemonnier, the president, recently delivered to the members of the syndicate. According to this authority the total capital employed in electric lighting and transmission of energy in France is £2,640,000, of which sum £2,600,000 is represented by electric lighting, leaving only £40,000 to the other application of electricity. In giving these figures M. Lemonnier explains that they represent the capital expended from the time that electric light was first introduced (about ten years ago) up to the present moment on machinery for the generation of electricity, on conductors, and on lamps. The pressure employed varies between 50 and 1,500 volts, and the currents are both direct and alternating. The total number of fatal accidents which have happened during the last 10 years in France, and which are directly attributable to the effect of electric shocks on the human system, is eight. A ninth case is doubtful, as it could not be ascertained whether death was caused by a shock or by the person becoming entangled in a belt. M. Lemonnier points out that in comparison with the capital employed, the electric lighting industry has enjoyed greater immunity from fatal accident than any other industry which could be named, and that there is therefore no need for special legislation by the State for the purpose of more effectually protecting life. As regards the protection of property, he points out that in the opinion of insurance companies, firemen, managers of theatres, and other persons of experience in the fire risks incurred by artificial lighting, electricity is much safer than gas, and no special legislation is needed on that account. He admits that for transmission of energy over long distances, where the cables have to be carried along public roads, or over ground outside the property over which the owner of the installation has control, some kind of legislation as to the manner of erecting and insulating the conductors would be desirable; but he is distinctly opposed to any legislation which would interfere with the details of an installation erected entirely on private ground. He is also opposed to limit the potential in any way, but he would agree to have the kind of insulation necessary for every potential fixed by law.

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ON THE DESIGN AND CONSTRUCTION OF DYNAMOS.

BY GISBERT KAPP.

(Continued from page 9, Vol. XVI.)

The output of a dynamo is mainly limited by the heating of armature and field magnet coils. The greater the efficiency the less energy will be wasted in overcoming the resistance of the armature and in providing the necessary exciting power for the field magnets; but some energy must always be sacrificed in this way, and the amount so lost is limited not so much by considerations of economy (although in many cases this is also of great importance) as by the capacity of the dynamo to dissipate heat. Say we have two machines of equal size, the one wasting 20 per cent. of the total electrical energy in heating the armature and field magnet coils, the other only wasting 10 per cent. If both machines have equal capacity for dissipating heat it is evident that the more economical machine can give twice the output of the other and yet work at the same safe temperature. This explains why a high coefficient of efficiency is of so much importance in dynamos. It not only enables us to work economically as far as the current expenses for steam-power, or other source of energy, are concerned, but it also enables us to make a small dynamo do the work of a large one, thus reducing the prime cost of the plant.

To make the efficiency and the output of a dynamo high, we have to attend to the three following conditions:—

1. Plenty of copper on the armature and proper cooling arrangements.
2. A very strong magnetic field.
3. An economical shape of field magnets.

These conditions are to some extent opposed to each other. Thus to put the maximum possible amount of copper on the armature we would have to cover it entirely with the coils, and this would prevent the passage of a cooling air current. Again, a very strong magnetic field requires a large amount of exciting power, especially if the thickness of armature conductor is considerable, because a large air space δ (*see* page 8, Vol. XVI.) produces of necessity a large magnetic resistance. The energy required to maintain the magnetic field will therefore be considerable. It is impossible to lay down hard and fast rules for best proportions, as so much depends on the particular type chosen. But by the aid of the formulas given in previous articles it is possible to determine the different items which affect the total efficiency, and by suitably varying the design those proportions can be found for which the sum of all the losses becomes a minimum. Generally speaking, a large armature is advantageous, because it enables us to use wire of large cross sectional area, it has a large cooling surface, and permits the use of internal ventilating passages, and the magnetic resistance of the air space is small on account of the large area of pole pieces which can be used. On the other hand, an increase in the size of the armature increases the cost of the machine rather more than an equivalent increase in the size and strength of the field magnets alone.

The third condition, that of an economical shape of field magnets, can be fulfilled without interfering, to any great extent, with the two other conditions. By the term economical shape we understand such a formation and arrangement of magnets that the energy required to excite them shall be a minimum. Now, in disc machines, there is not much scope for variety in the arrangement of the magnets. The general character in the design of these machines makes it convenient, if not absolutely necessary, to place the magnet cores parallel to and equidistant from the armature shaft around the circumference of the disc. This leads necessarily to a multiple system of magnets with two common yokes, which form at the same time the end plates of the frame. All we can do to minimise the amount of wire in the magnet coils is to make the cores of circular cross section, because of all closed figures the circle is that containing the largest area in a given perimeter. With drum and cylinder armatures the case is different. We have generally two pole pieces, and four different types of magnets can be used.

1. A multiple of single horseshoes, having a common yoke, and two common pole pieces, as in the original Edison dynamo.
2. A multiple of double horseshoes, having two common yokes, and two common pole pieces, as in the original Weston dynamo.
3. A single horseshoe, as in the improved Edison-Hopkinson dynamo.
4. A double horseshoe, as in the Siemens, Crompton, later type of Weston, and other dynamos.

The first and second arrangements are faulty, for the simple reason that the sum of the perimeters of a number of cores of small diameter must necessarily be larger than the perimeter of a single core, the area of which equals the sum of the areas of the small cores. Consequently, multiple magnets require more wire, and absorb more exciting energy than simple magnets.

The third arrangement (*see* page 250, Vol. XV.) is the most economical of all, as can easily be proved by comparison with the fourth arrangement (page 251, Vol. XV.). We found that the strength of field for a single horseshoe is given by the formula,

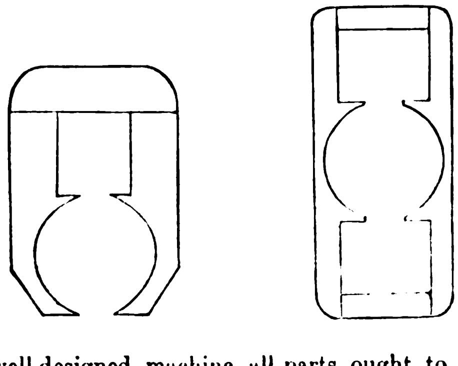
$$Z = \frac{P}{\frac{2\,L}{A\,B} + \frac{l}{a\,b} + \frac{1{,}440 \cdot 2\delta}{\lambda\, b}}$$

If we were to construct an equivalent field of the double horseshoe pattern, L^1 would be little more than half, and the area $A^1\,B^1$ would be exactly half as large as in a single horseshoe, l, a, b, and δ remaining the same, whilst λ would be halved. The strength of half the field would in this case be

$$\frac{Z}{2} = \frac{P}{\frac{2\,L^1}{A^1 B^1} + \frac{2\,l}{a\,b} + 2\,\frac{1{,}440 \cdot 2\delta}{\lambda\, b}}$$

In the double horseshoe the total magnetic resistance is therefore very nearly twice as large as in the single horseshoe, and since the number of lines is halved it follows that the exciting power in both cases is equal. But in the double horseshoe this exciting power has to be applied on two magnets, whereas in the single horseshoe it has to be applied only on one magnet, the perimeters being in the ratio as 1 is to $\sqrt{2}$. The double horseshoe requires, therefore, about 40 per cent. more wire than the single horseshoe, and allowing for an equal density of current in the wire, the exciting energy will also be about 40 per cent. greater.

A double horseshoe machine has, however, the advantage of being somewhat lighter, as will easily be seen on comparing the annexed sketches. In the single horseshoe the radial thickness of pole pieces measured on the magnetic axis must be at least half that of the magnet core, so as to provide sufficient area for the flow of half the lines. In the double horseshoe no lines flow past those points, and the thickness of the pole pieces can there be reduced to a minimum consistent with mechanical strength.



In a well-designed machine all parts ought to be equally safe as regards over heating, or, in other words, the same maximum working temperature should be reached simultaneously in field magnets and armature. It would obviously be useless to provide an armature capable of carrying the full working current for an indefinite period, if the carrying capacity of the field coils is so small that

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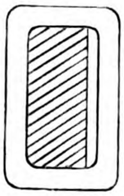
they become dangerously hot after a few hours' run. On the other hand, however much cooling surface we might provide on the field magnets, we cannot take advantage of it if the armature has not enough cooling surface or not enough internal ventilation. From these considerations, it follows that for the armature, as well as for the field magnets, there exists a certain definite, though not necessarily the same, limit for the ratio between cooling surface and energy transformed into heat. The determination of these ratios is purely a matter of experience, and is peculiar to every type of dynamo. As a rule, field magnets arranged vertically require less cooling surface than those placed horizontally, because the heated air can more easily ascend and be replaced by fresh air. The field coils, when vertical, can also be effectively cooled on the inside by a device intended for cases where the dynamo has to work in a hot room. This device consists simply in making the internal width of the coil slightly larger than the corresponding thickness of the magnet.

In the annexed sketch the shaded portion represents the cross section through the magnet core, which is surrounded by



a rectangular coil wound on a separate sleeve. This sleeve is about half an inch wider than the thickness of the core, leaving thus an internal air shaft open at both ends. These air shafts (which are arranged on the outside of the two vertical magnets, and not on the inside, where the hot air discharged from the armature would be of little cooling value) act in a measure as chimneys, creating a gentle draft of air past the inside of the coils. It will be noticed that the waste of wire entailed by this arrangement is only about one inch per turn, an insignificant amount in large dynamos where the length of one turn in the exciting coils is a yard or more. It need hardly be mentioned that such air shafts would be useless in horizontal machines. As regards the armature, the capacity to dissipate heat depends very much on the surface speed, and on the ventilating arrangements. For dynamos working in cool places and so constructed that air is freely admitted to the armature; the cooling surface provided should be from ·8 to 1 square inch for every watt transformed into heat. By the term "cooling surface" is meant the whole surface of winding exposed to the air, both inside and outside, and the rule refers to armatures having a peripheral speed of from 2,000 to 3,000ft. per minute. Field magnet coils require from 1·5 to 1·8 square inch per watt. It should be borne in mind that these figures are only rough approximations, and may in special cases have to be considerably modified. Thus it is the author's practice to allow in dynamos intended for ship work (where the machines are often placed in hot and badly ventilated rooms) from 1·5 to 2 square inches per watt for the armature, and from 2 to 4 square inches per watt for the field coils.

The number of watts transformed into heat are calculated in the well known way by multiplying the square of the current with the resistance. Now, as regards the armature, this is simple enough, because we have to deal with one winding only, and moreover the size of the conductor is generally predetermined by the loss of E.M.F. we may choose to allow. The number of turns is also more or less a predetermined quantity (found according to our formula for E a), and therefore the investigation as to heating must be undertaken, not so much with the object of working to a definite ratio between energy lost and cooling surface, as with the object of finding whether we have sufficient cooling surface. With the field magnets the case is different. Here we can work from the outset to a definite rate of so many square inches per watt, and we can determine on this basis the amount of copper required to produce a given exciting power. How this amount of copper is to be distributed in the shape of a coiled wire (or two coiled wires in the case of a compound machine) is simply an algebraical investigation, and need not be at length described. For the purpose of making a preliminary estimate as to the amount of copper required, it is sometimes very useful to have a simple formula, which should give this as a function of the exciting power required, the energy allowed to be wasted in heat, and the dimensions of the coil. The following is such a formula :—

$$a = 7 \frac{\pi P^2 10^{-7}}{W}$$

where W represents the number of watts wasted, P the exciting power in ampere turns, π the mean perimeter of the coil, and a the aggregate cross section of all the wires in the coil in square inches. The total weight of copper in the coil is then given in pounds by the product $\cdot 32\, a\, \pi$. Knowing the shape of the section of the magnet and the length of the coil, we can, by assuming a certain thickness of winding, calculate, in the first instance, an approximate value for the cooling surface. This, combined with the predetermined ratio of square inches per watt, gives the total number of watts W which can safely be transformed into heat. The value of a can then be calculated and the winding determined. If its thickness should greatly differ from that first assumed, a new value for W must be calculated and taken as the basis for the final determination of a.

TELPHERAGE.*

BY PROF. JOHN PERRY, F.R.S.

(Concluded from page 326.)

From my preparatory lecture you will understand that when the motor is running at its normal speed of 1,700 revolutions per minute, requiring, say, a current of eight amperes, the speed is diminished on account of the train going up hill. The motor will receive a greater current from the engine house, and this means that in going at a slower speed it is able to exert a much greater effort; and we find that the train diminishes its speed only a very little when it finds that an extra effort is required sufficient to draw it up an incline of 1 to 13. The fall of potential along the telpher line, of which I spoke to you in my last lecture, and which is so very serious in electric lighting, was feared by us at first, as it was probable that trains near the engine house would move much faster than trains which were farther away. But we have got over this difficulty by an electrical governer, a most ingenious contrivance of Prof. Jenkin's, which is attached to each locomotive. You will understand the construction of this governor from Fig. 23.

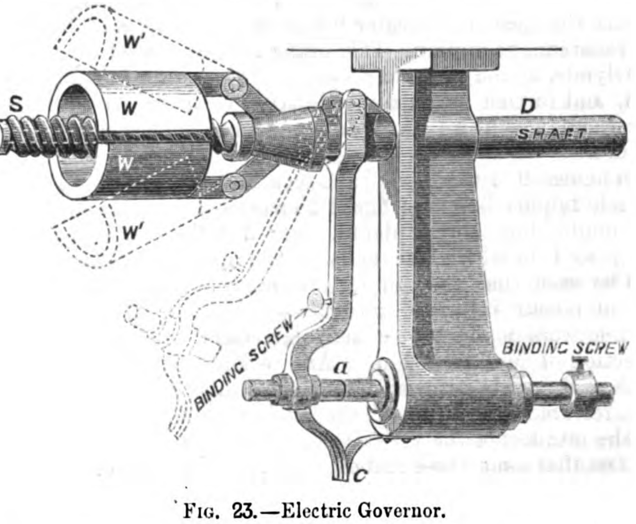


FIG. 23.—Electric Governor.

D is the second shaft and W W the two weights of a centrifugal governor, which are held in positions near the axis by means of

* Lecture delivered at the London Institution, 28th January.

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the spring S. When the masses W W fly apart into position W′ W′, they draw the lever into the dotted position and break the metallic contact at *c*, so that no electricity can be received by the motor. The weights of the governor are so hung that if, for example, they fly out against the pressure of the spring at a speed of 1,700 revolutions, they fly out very far, and the break at *c* is performed very rapidly. But no spark occurs at *c*, because after the contact is broken there, there is a contact maintained for a short time between two carbons at *a*, or a piece of carbon and a piece of iron, one of which is compelled by a spring concealed in the frame to follow the other for some distance. If the contact be suddenly broken when the motor is making 1,700 revolutions per minute, contact will not be restored again until the speed of the motor has become reduced to about 1,500 revolutions per minute, so that the electric current is cut off during this interval. Whatever, then, be the potential difference at the terminals of the motor the governor keeps the motor running at a speed of between 1,500 and 1,700 revolutions per minute. But inasmuch as going down steep inclines the train has power to propel itself without receiving any electricity, we have also placed on one of the shafts A A the brake shown in Fig. 24, where W B, W B

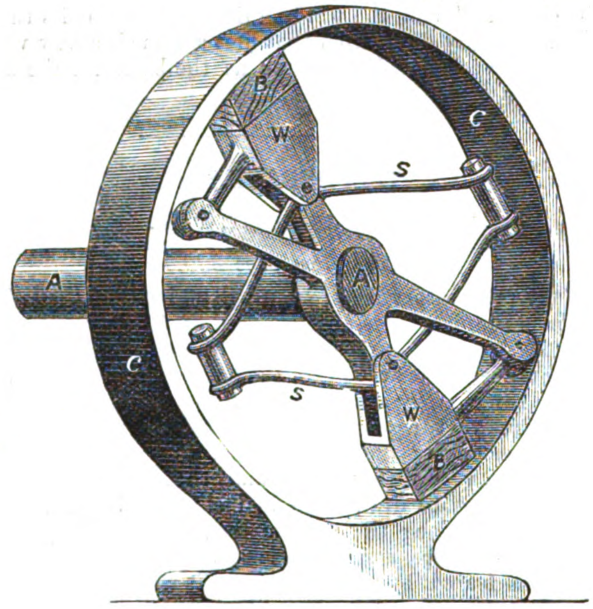

Fig. 24.—Mechanical Brake.

are two weights whose centrifugal force up to a certain speed is balanced by the springs S S; but above that speed, which corresponds to about 1,800 revolutions of the motor, the wooden brake-blocks B, B press against a fixed metal ring C, the greater the speed the greater being this pressure, and therefore the resistance to motion. This brake is rarely called into action at Glynde, as the electric governor performs its function very well, and further renders any description of the other electric governors which we have designed also unnecessary in this lecture.

In figures 9, 10, 11, you have seen the posts employed in the Glynde telpher line, and figure 25 shows the usual support for this double line more in detail. At A A the cast iron saddles are placed to which the ends of the rods are fastened It will be seen that the supports require only a very unskilled sort of labour in their construction; indeed, all the posts at Glynde were made by common labourers working under the direction of Mr. Anderson. And when the Honourable Mr. Arthur Brand, in his speech on the opening day of the Glynde line, referred to the marvellous quickening power of electricity on the intellect of the agricultural labourer, he was referring to the fact that some Sussex labourers had become skilled workmen during the erection of the line.

The depth to which the supports must be sunk in the ground depends on the nature of the soil. At Glynde they are sunk to a depth of from four to five feet, and each of them has a worn out railway sleeper placed underneath it. In harder ground the sleeper would not be used, nor should we sink the supports to such a great depth. In many parts of India or Egypt we should probably have the part of the support which enters the ground made of metal; but indeed these supports, having to carry as they do only very small loads, may be constructed in many different ways, depending on the materials to be found in the district where a telpher line is to be erected. At first the saddles placed on the support were made so that they could rock slightly; but we now find that it is better to fasten them rigidly to the post, the post itself yielding sufficiently.

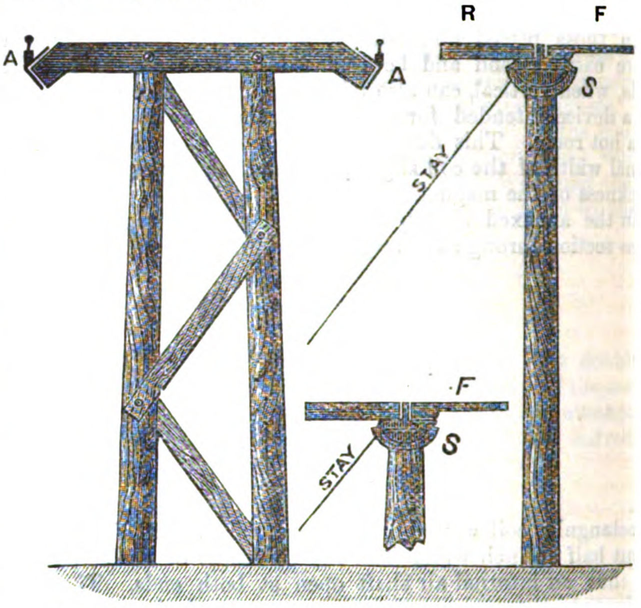

Fig. 25.—Ordinary Post. Fig. 26.—Abutment Post.

Fig. 26 shows what we call an Abutment Post, of which there may be one at the end of each curve. The saddle S

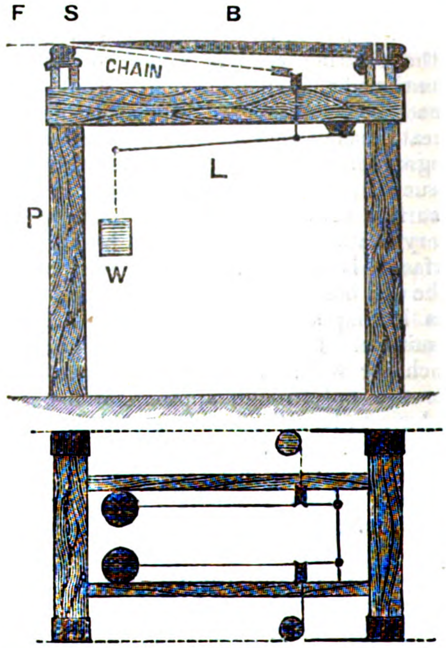

Fig. 27.—Elevation and Plan of Compensating Gear.

carries on the one side the end of the flexible rod F, used along the greater part of the line, and on the other side the end of the stiff rail R, which (as seen in Fig. 12) is employed along the curves. The abutment post is anchored back into the ground by these two tie-rods, which may be shortened or lengthened by turning these nuts; and these stays enable us to give any tension we please to the rods of the line. At different points of the line we place what is called a *Compensation Gear*, shown in elevation and in plan in Fig. 27. In this the post P may be regarded as an abutment post, by means of

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which we can alter the tension in the line to the left. But it will be seen that the flexible rod F is not fastened to a saddle at the top of the post P, but is fastened to a chain which is pulled by means of a lever, L, and a weight, W, so that the tension in the rod F is maintained as nearly as possible at 2¼ tons. Should the tension at F be greater than 2¼ tons, the lever rises, letting the rod F slip over the little saddle S. This compensation gear then causes the tension of the rod F to remain at about 2¼ tons, however many trains may be on the line, and whatever may be the temperature. The stiff blade B is made of steel, and rests on F in such a way that a train can readily pass from F to B or from B to F, and yet F has freedom to move on the saddle when the tension varies. At Glynde we have four such compensation gears, but experience shows that two of them per mile are all that are required, and this smaller number we propose employing in the next telpher line.

For future telpher lines I hope that it may be possible to obtain the 66 foot lengths of flexible rod in complete lengths from the manufacturer. The flexible rods at Glynde, made of ¾in. basic steel, have each at least three welds in them. I have heard that some complaints have recently been made as to the behaviour of basic steel; but I wish to say that the behaviour of this steel in the rods at Glynde has been marvellously good. The rods as originally designed came in two lengths, each with a forged end, and the two lengths were welded together at Glynde to make one rod. After the erection of the line it was found that although each of the rods before it was erected had withstood a severe test in a specially constructed testing machine, yet in the actual work of the line seven or eight fractures occurred in the forged ends in about two weeks All the rods were therefore taken down, the forged ends cut off, and pieces of round rods put on with their ends turned down as you see in the diagram, and not one single case of fracture has occurred since that time, nor has any rod been fractured at a place where a weld was made in a field at Glynde. That three welds should be made in each of 130 rods of basic steel so carefully that not one of them has broken during the last three months of constant work, despite the great loads to which they are subjected, shows that the smith, whose name is Hindell, and who came from Middlesborough, performed his work with an amount of faithfulness which may be regarded as wonderful in these days. In future, however, telpher rods will be made without any welds. These long rods may be sent in a rolled up condition, or bent at one or more places, depending on the distances to which they may require to be carried from the steel manufactory.

Although the survey and levelling of the line had been only roughly performed—and, indeed, at one place we found ourselves some four feet wrong in the heights of the posts—yet I had no difficulty in fixing the lengths of the rods to just give the tension wanted everywhere in the line. This ease in construction was greatly due to the yielding of the posts and to our having abutment posts and compensation gear.

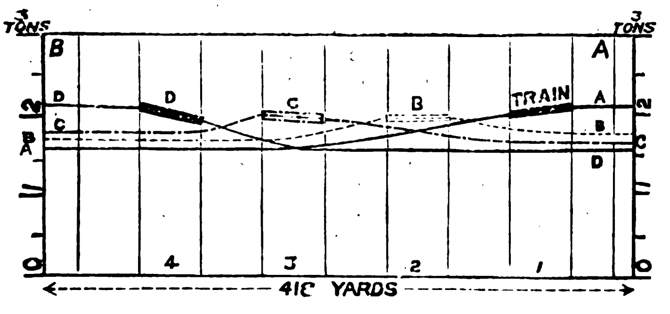

FIG. 28.—Diagram of the Tensions in the Line.

In Fig. 28, curve A A A shows what is the tension at every part of a section of a line when the train, which covers two spans, or 132ft., is at 1, vertical distances representing the tension in tons in accordance with the scale shown at the side. Curve B B B shows what the tension is at every part of the line when the train is at 2

Curve C C C when the train is at 3.
„ D D D „ „ 4.

In this particular section of the Glynde line the compensation gear, which was placed at the end B, had just been erected, before the measurements were made whose results are shown on the diagram, so that all its joints were stiff, and it, therefore, did not maintain so constant a tension at its end of the line as it did a little later. It will be seen, however, that the tension in a rod is greatest towards the two ends of a section when a train is approaching either of those ends. In making a measurement of the tension in a rod at any instant, unless a loaded train is on the rod, the measurement was at first very difficult, and I thought that I should find it necessary to design a complicated instrument to do this, as it was absolutely necessary to make such measurements for the adjustment of the line. I discovered, however, that I could use what may be called a *fiddle-string test*, depending on the fact that when the rod is allowed to vibrate, it vibrates more quickly the greater the tension in it. I found that some of the labourers could be trusted to measure the tension in any of the rods by setting the rods swinging, and by measuring the number of the vibrations made by the rod in ¼min. Twenty-five vibrations meant that there was a pull of 1 ton,

30 vibrations that there was a pull of 1·44 ton.
35 „ „ „ 1·96 „
37 „ „ „ 2·25 „

We have taken pains that in the usual working no rod in the whole line, no matter where the train may be, shall have greater tension in it than 2¼ tons, and this allows for a considerable factor of safety, as we have tested the line with much greater loads than this.

To make permanent electrical connection between the steel rods at the cross-overs (see Fig. 8) has proved to be a matter of considerable difficulty, and the method which I have adopted at Glynde, although it is successful, is one which I am not particularly proud of, and I feel sure that some simpler method may be adopted in future. We have bored a slightly tapering hole through a part of the steel rod where it is not much strained, and driven in a plug of copper, which is sufficiently long to have a thick copper wire soldered to it on the outside, and to have a head riveted on the smaller end. At first we brazed these plugs of copper into the steel rod, but subsequently they were only riveted in.

I think that I have now mentioned most of the details of the flexible parts of the line. It only remains to say that at sharp curves, and at the two ends of the line, we find it convenient to use, instead of flexible rod, a stiff bulb angle iron, as seen in Fig. 12. This rail of angle iron is supported by posts 13ft. apart, and the bulb angle iron rests on the wood directly, or else on an insulator attached to it at the post. Both plans are in use at Glynde; but we have found that the insulator may be dispensed with. When, however, at every fifth post the new section occurs, which must be insulated from the former, and where, therefore, the end of the rail on one section must be insulated from the end of the rail near it belonging to the other section, we use an insulator and a saddle somewhat of the shape of the insulator and saddle shown in Fig. 14. In one place where a brook has to be bridged, instead of placing these posts at 13ft. apart, they are placed at 26ft. apart, a supplementary angle iron being riveted underneath the usual two lengths to give the necessary strength.

A very effective form of siding was tested at Weston, and found to answer. It consists of a hinged stiff blade of steel, which connects a stiff siding with the main line at any place when it is lowered down so as to rest on the line. Sidings of this kind will be introduced at Glynde, should they be found necessary, after a while. In concluding this description of details, I may say that it would now be possible for the staff of the Telpherage Company to order material, to examine this material before it left the factory, and to erect a line of any length of the Glynde type in such a way that no hitch of any kind would be found to occur in the erection, and that not one bolt too few or too many would be sent from the manufactory, and that the line would work perfectly on first being

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tried. We know to a great nicety the cost of the materials, and of the erection of telpher lines. We are more doubtful as to the cost of steam power, and of wages; but using the highest figures likely to be taken by any critic for steam power and wages, I find that the total cost of a telpher line whose length is x miles of double track, and which carries y tons of material per annum in one direction, the skeps coming back empty, is expressed in pounds sterling by

$$275 + 350x + \cdot 027\,xy,$$

and the working expenses in pence per ton-mile of material carried by

$$\frac{46,800}{x \times y} + \frac{23,184}{y} + 1 \cdot 85,$$

fifteen per cent. per annum on the capital expended being included for interest and depreciation. Thus, for example, to carry 84,000 tons per annum—which is the limit of carrying power which I should advise for a telpher line like the one at Glynde, as it places the trains six spans apart—the cost per ton-mile is $2\frac{3}{4}$d. if the line is only one mile long, and it is only $2\frac{1}{4}$d. if the line is ten miles long. To carry 42,000 tons per annum 10 miles the cost is $2\frac{1}{2}$d. per ton-mile, but if the line is only one mile long the cost is $3\frac{1}{2}$d. In fact, it may be said that on a railway the carriage of goods may be done at the rate of about 1d. per ton-mile if there is a sufficient amount of traffic; that on a telpher line the cost is from $2\frac{1}{4}$d. per ton-mile upwards, in many probable cases being from 3d. to $3\frac{1}{2}$d.; whereas cartage cannot be performed at much less than 1s. per ton-mile, and in even at this much higher price the cost of constructing the cart-road and keeping it in repair is left out of the account.

And now that you have had a description of the telpher line at Glynde, and seen the slides taken from the photographs of the line, you will understand the significance of this quotation from an article in *Nature* of last November.

"On Saturday, Oct. 17, a special train from Victoria conveyed a party of about 200 guests, among whom were many leading electricians, engineers, and other well-known men of science, to Glynde, in Sussex, to witness the ceremony of the opening of the first telpher line erected in this country. The ceremony was performed by the Viscountess Hampden, and was of an exceedingly simple character. On lifting a small box, containing a present which the Chairman of the Company invited her ladyship to accept, electric communication was instantly established between the dynamo in the engine house, and the telpher line, and a garlanded train loaded with clay at once began to move up an incline towards the Glynde Railway Station, amidst the applause of the assembled spectators. Whether this ceremony, which brought so many distinguished visitors down to Lord Hampden's estate on Saturday is the inauguration of a great commercial enterprise is beyond our province to inquire, but it is unquestionable that the slight flash seen when Lady Hampden lifted the little box lying on the table in front of the engine house marked the beginning of a new departure in electro-technology."

When a telpher train is first seen running it is very difficult to understand its method of propulsion. The train's flexibility as it moves along the line at $4\frac{1}{2}$ to 5 miles per hour, and the unlikeness of telpherage to any other method of propulsion, the train appearing to be a long living thing of the snake species, are so remarkable that when it is announced to be a method of electrical propulsion, it is probable that the electrical engineer is at first more astonished at it and more unable to comprehend its action than anyone else. An empty train at Glynde will travel to the clay field, where it sinks down nearly to the level of the ground; the labourer touches a key and so stops it; the skeps are filled with clay, the key is touched again, and the train starts off round the stiff rail in the clay field, soon getting to the flexible part of the line again, and steadily wending its way to the railway siding, where, without stopping, it drops its loads into the railway waggons. It then passes round the stiff rail end in sight of the railway bridge, and travels steadily back to the clay field, all the time—whether loaded or empty, whether going up hill or down hill—travelling at the same speed of about $4\frac{1}{2}$ miles per hour. It was unfortunate that only one river had to be crossed (seen in Fig. 10), since had there been more the advantages of telpherage would have been even more exemplified. Sometimes, however, during the winter, some of the fields over which it passes are several feet deep in water, and if repairs had to be effected it would be necessary for the men to go in boats or rafts to the line, so that on the whole it passes over a fairly watery country. Looking at the ground it is very difficult to see how it would have been possible to carry this clay in any other manner than by telpherage, without building a very expensive road with a bridge over the river to the railway station. I am happy to say that the telpher line was erected while cattle were grazing in the field over which we run, and that the compensation for damage done which we were required to pay, and which was principally due to some of our workmen taking short cuts across fields instead of the regular paths, amounted in all to only £25.

It must be remembered, too, that if a turnip cutter or a shearing machine, or a thrashing machine, a winnowing machine or a plough, or any other agricultural tool, requires to be worked, it can be driven by attaching an electro-motor to one of these supports and connecting it by means of two little wires with the rods at the top of the posts. Thus, on the exhibition day at Glynde, a turnip cutter was being driven from the line by means of this very little motor which you see on the table, without interfering with the regular working of the trains. Now it must be borne in mind that the capital cost of the line itself, or permanent way, is a comparatively small part of the cost in telpherage, and that, in reality, the expense is in the trains and in the dynamo machines which drive them. Now, suppose that such a line as the Glynde line of 1 mile long is built, and we start with 3 trains, each train will carry 6,000 tons in one direction in one year; but should it be required that instead of carrying 18,000 tons per year the line should carry 24,000, or any other number of tons per year, it is only necessary to add the required number of trains, and if the dynamo machine already existing is not sufficient a new one has to be added. In fact, it is a system in which the capital cost will increase in a proportion which is not very far from being that at which the work to be done is increased. It is to be remembered that we can pass over gorges in mountains and up and down steep inclines over very uneven ground, that there is no difficulty in going round even very sharp curves, such as introduce enormous wear and tear and friction in the wire rope haulage system; and that, although I have told you of weights, each of which was less than 3cwt., yet we can design lines, especially when we use stiff rails, to carry almost as much as we please. Our source of power may be near the line and preferably near the middle of the line; it may be a steam engine or a water wheel, or it may be placed at several miles from the line.

The inquiries which have come to us about telpher lines show that it may be used in many more ways than those of which we thought at the beginning. As we have it at present, it will not only be very useful in bringing ore from mines, but it is easy to arrange for a telpher line which will load or unload a vessel which is unable to come close to shore on account of the shallowness of the water, and we can imagine these trains of skeps running out over the sea, running down into the hold of a vessel, running up again, and coming back to land.

The immediate application of telpherage is not, I think, very likely to occur in a country like England, where the common roads and railways and tramways are already so numerous that telpherage can only be worked probably for short distances to feed the railways. But consider a country which has few roads and railways, a country like Japan, a country teeming with population, where, excepting in the neighbourhood of the treaty-ports, the roads are not much better than bridle paths, where the only method of conveying goods is on the backs of the coolies or on pack-horses. The price of rice and other materials is vastly different at a seaport in Japan where the steamers call from what it is in the middle of the country, and when we consider the small load that a pack-horse will carry on its back, and the price which must be paid per mile, it will be seen that a system of telpherage, by which goods would be

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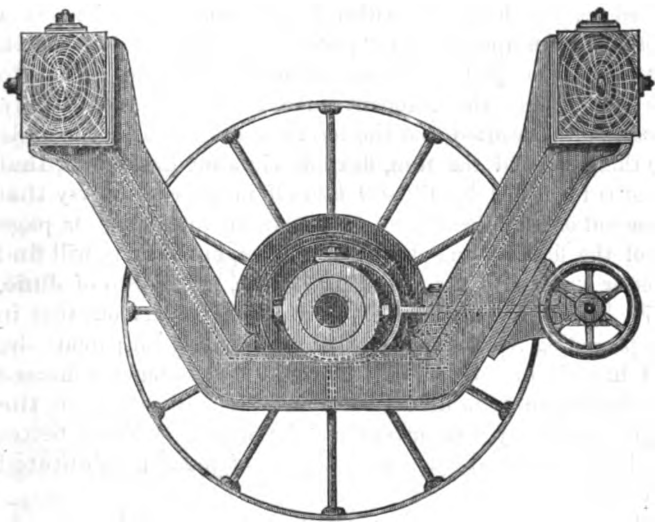
carried at from 2d. to 4d. per mile, or at cheaper rates if worked by waterfalls instead of steam engines, would lead to the development of a country which did not possess capital enough to build railways or even to make common roads. Military men have told us that the use of a telpher line would be nearly invaluable in bringing stores up to the front in a military expedition, and, indeed, when at an evening party, at my own house, about a year ago, this model which you see before you was exhibited to my guests, some of them told me that it saddened them to think that telpherage had not been sufficiently developed before that time for the crossing of the desert from Souakim to Berber.

We have at present very modest aims. I should prefer for some time to simply develop lines like the one at Glynde; but I am quite sure that in future, when more capital than we have had at our command is employed to develop the system, we shall have trains of skeps passing down empty into coal mines and along the workings, to be filled by the men as they dig the coal from the face, come back to the bottom of the pit, and, moving up a vertical rod, pass on to the ordinary lines at the surface, and without stopping, except, perhaps, to be labelled, travel along, shunted from point to point by men properly stationed, who will know what to do with each train by seeing the ticket stuck upon it, and will eventually reach the door of the customer who is to use the coal. The immense amount of worry which there has been in the development of telpherage, even as we now see it, shows me that its grandest developments cannot come in my own time, but that it must come in the long run, and that telpherage will be a general system of distribution of goods is a fact which is fixed in my mind so securely that no amount of disappointment or worry can remove it.

ELECTRIC LIGHTING AT MANCHESTER.

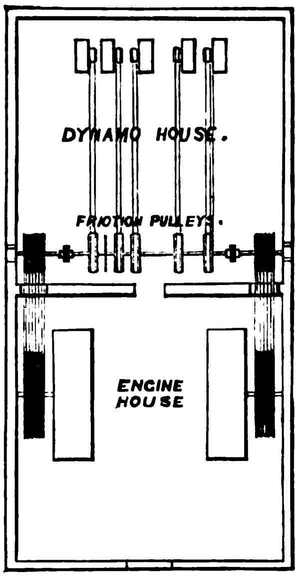
The large buildings recently erected by the Lancashire and Yorkshire Railway Company for their new offices at Hunt's Bank, Manchester, are fitted throughout with the electric light. The generating station is situate at the back, near to, and below the bed of, the River Irwell, where excavations were made for the necessary accommodation. A couple of locomotives have been renovated and transformed into a capital type of semi-portable engine, each being supplied with fly-wheel grooved for eight ropes, and arranged so that the machinery may be driven from either engine.



End View—Countershaft and Hangers.

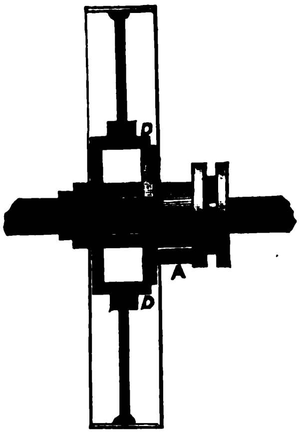
The counter-shaft, 3¾in. diameter, spans the dynamo house and revolves at 350 turns per minute in self-lubricating pedestals suspended by hangers from polished pitch pine beams overhead.

Four dynamos are employed in charging accumulators for passenger trains and for the lighting of the offices. By the use of Bagshaw-Addyman friction pulleys, as shown, any machine may be stopped or started whilst in motion without moving the belt and without shock. These pulleys are bushed with phosphor bronze, and are each capable of transmitting 40



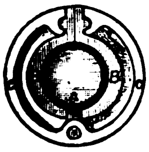
Plan, Electric Light Installation, L. and Y. Railway.

indicated horse-power. They are instantly connected or disconnected by the simple insertion or withdrawal of a wedge,



Longitudinal Section—Friction Pulley.

operated by a hand lever. When running at full speed with all power on, everything keeps cool and works smoothly, evidence



Transverse Section.

of good work and perfect balance. In the transverse section B B shows the levers opened out by the pin A, thereby expanding the friction ring C.

Societe Internationale des Electriciens.—Owing to the great increase in the number of members of the International Society of Electricians of Paris residing in England, the Council of the Society have appointed one of their members, Mr. R. Aylmer, M.I.C.E., A.S.T.E., of 42, Parliament-street, S.W., as hon. secretary and treasurer for Great Britain.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

ANSWER TO CORRESPONDENT.

T. BILHAM.—*The results depend upon the conditions. If the person is well insulated we doubt if there is any danger in touching the wires with one hand with the usual machines. The person may, if not well insulated, form part of a shunt circuit, and contact, even with one hand, may be dangerous.*

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THE BASSANO TELEPHONE JUDGMENT.

The decision in the case of the UNITED TELEPHONE COMPANY *v.* BASSANO was given so far back as last August. Mr. Justice NORTH, therefore, cannot be accused of haste in the preparation of the elaborate and formal judgment he has just delivered, and which we print in another part of this paper. The first thing that strikes an impartial observer about this judgment is the absence of any attempt to find out what the patentee, whose specification was the subject of the alleged infringement, meant by the terms he used. The patentee in question was Mr. EDISON; the specification was that relating to his "instrument for transmitting electric impulses by sound," since re-christened "the carbon telephone," the alleged infringement being the well-known apparatus of BASSANO and SLATER, having pencil microphones of hard electric light carbon placed across the bottom of a conical wooden tube, which rested in a socket attached to a back board of red wood.

EDISON'S specification above referred to is a very remarkable document. The instruments described and claimed by it are nowhere called "carbon telephones"; they are not denominated "telephones" at all, that term being reserved for the receiver; nor is the substance "carbon" ever once mentioned from first to last. Of the thirty claims which originally accompanied the specification, twenty-nine have since been struck out, leaving one claim only, and that one limited by a significant disclaiming clause preceding it. The surviving claim runs thus:—"I claim, in an instrument for transmitting electric impulses by sound, the combination with a diaphragm or tympan of electric tension-regulators substantially as hereinbefore described for varying the resistance in a closed circuit, substantially as set forth." The preceding clause runs thus:—"I will observe, in conclusion, that I do not claim generally the transmission and reproduction of sounds by increasing and decreasing the resistance of the circuit, nor do I claim separately any of the parts or arrangements hereinbefore described and illustrated in the accompanying drawings, except as hereinafter mentioned."

Now, with this emphatic disclaimer both of general principle and of separate details before him, limiting the claim solely to the combination of one detail with another detail of the instrument, the learned judge would naturally be expected to inquire most carefully into the actual meaning intended by the patentee to attach to the terms in which he described the two essential elements of his combination. And it should have been, at least in one respect, an easy matter to decide this point. The prior history of telephony would have helped; and EDISON'S own letters of 1878, in the famous HUGHES-EDISON controversy, would have made clear the meaning he attached to his own words. The terms "diaphragm or tympan," used as synonyms by EDISON for one of the two essential elements, are sufficiently explained in the text of the specification. The tympan was to be "like a drum." It must be—to judge by the numerous drawings—a real drum-head, circular, flat, thin, attached at the edges, bending under the influence of the voice, and if not made, as recommended, of mica, must at least be flexible like mica. The history of telephony would have revealed successively the parchment drum-head of the "lovers' telegraph," the membranous diaphragm used by REIS in imitation of the ear, the goldbeaters' skin diaphragm of GRAHAM BELL'S earlier, and the thin iron diaphragm of his later instruments.

All these were well-known prior to EDISON'S patent. EDISON nowhere hints that his diaphragm or tympan was anything more than these. He mentions, indeed, in one place, another kind of mechanism to be placed inside a speaking tube, a metal plate clamped rigidly near its centre, and free to vibrate at its edges, but he never called it a "diaphragm;" he put a separate claim upon it as a "plate;" and then, later, struck out the claim, just as he struck out the claim for adding to the instrument the resonant tube or mouthpiece. Were further proof wanted that the term diaphragm did not include anything beyond the thin, flexible, vibrating drum head, that proof is furnished by EDISON himself in the controversy that arose out of the invention of HUGHES'S microphone. On page 70 of the first volume of *The Electrician*, our readers will find a letter written to the *New York Tribune*, on the 8th of June, 1878, by Mr. EDISON himself, in which he points out that in the preceding April—ten months after his English patent—he had himself discovered that he could with advantage discard the diaphragm from his instrument. "The discarding of the diaphragm is my own invention," he wrote. "Much better results are obtained when a rigid plate of metal is substituted in its place."

Mr. Justice NORTH has apparently proceeded on very different lines to find a meaning for EDISON'S terms. Oblivious of all the work done by GRAHAM BELL, and before him by REIS, he declares EDISON to be the original inventor of the speaking telephone, and as such entitled to have the widest interpretation put upon his language. EDISON said that he might have one or more diaphragms at the ends or sides of the resonant chamber, and they might be of different sizes; Mr. Justice NORTH forthwith decides that anything at the sides or

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ends of the chamber is a diaphragm! Even a microphone pencil is a diaphragm. The doctrine of "benevolent construction" could hardly be stretched beyond this. Even if it were true that EDISON was the first to construct an electric speaking telephone, any grounds for benevolent construction—or, in other words, judicially giving to an inventor more than he has claimed, or is entitled to—would be effectually disposed of by EDISON'S own disclaimer of general principles. The man who, in order to outrival GRAHAM BELL, was instructed—as he himself has stated on oath—by his employers, the Western Union Telegraph Company, to remodel REIS'S telephone, is now held up as the original inventor, and *therefore* everything is to be benevolently strained in his favour.

This decision is the more regretable, we think, because it is the triumph of a wealthy monopoly over a poor inventor. Mr. BASSANO is known and respected as a modest and hard-working telegraph engineer. He had, it is plain, honestly imagined that when EDISON said "diaphragm" he meant "diaphragm," and did not mean a "tube" or a "pencil," or anything but a "diaphragm." He is now made the victim of a judicial pronouncement which has so strained the definition of a diaphragm as to make it include all of these things. Mr. BASSANO has been unfortunate throughout in this action. Of the two eminent counsel whom he sought to retain to defend him, one was unable to take up his brief; the other deserted the case to go on circuit. Against him he had the ablest of counsel and the most eminent of experts. These gentlemen went through the solemn performance of tying the two ends of a string to two conical wooden tubes, into one of which they talked, while their words were heard at the other, as in the old lovers' telegraph. Upon this they founded the following amazing syllogism:—If you talk to a diaphragm it vibrates; if you talk to a tube it vibrates; therefore a tube *is* a diaphragm. Mr. Justice NORTH calls this a most conclusive experiment, decides that a tube is a diaphragm, and Mr. BASSANO has to pay the costs. Mr. Justice NORTH, indeed, went further. Everything is a diaphragm if the air-pressure on one of its sides is different from that on the other. That is the newest legal definition of a diaphragm, and it will include everything, from a flying bird to a burning candle. We are of course unable to accept this as a scientific definition, and we regret it as a legal deliverance on public grounds, partly because it was obtained by a rich and powerful monopoly, and partly because it will tend to establish that monopoly more firmly than ever.

CORRESPONDENCE.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A fortnight ago the writer to whom I had replied recanted the first of his mistakes, viz., the use of 736 instead of 746 as the number of watts in the horse-power. This week he so far relaxes on the second point as to condescend to say that he prefers to call "the proper working speed" that which I and others had consistently been calling "the critical speed;" and I perceive that he no longer insists that a dynamo that is only partially self-excited cannot have a critical, *i.e.*, a proper working speed. This being so, my aim in addressing you has been attained. But the writer goes further and now attacks the theory of the self-regulating motor, a matter which is outside the two points of correction about which I wrote. His doubts as to the correctness of the theory in general come a little late in the day, inasmuch as the theory and the equations of the self-regulating motor were propounded so far back as 1883 by my friends Profs. Ayrton and Perry.—Yours, &c.,

SILVANUS P. THOMPSON.

Finsbury Technical College, 29th March, 1886.

THE DIGNITY OF SCIENTIFIC DISCUSSION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is high time that a word of warning should be spoken against a growing tendency lowering to the tone and character of discussion in the Society of Telegraph-Engineers and Electricians. The society holds its meetings in the theatre of the Institution of Civil Engineers, and a comparison between the proceedings of the two learned bodies naturally suggests itself. Comparisons are proverbially odious, but they may at times be also very instructive, and I venture to assert that the Telegraph Engineers have as a body a great deal to learn from the Civil Engineers in the matter of carrying on discussions with that decorum and courtesy which should be a kind of second nature with any assembly of scientific gentlemen. A few weeks ago the members were treated to the spectacle of two learned professors wrangling with and contradicting each other across the President's chair; and only at the last meeting a person got up, in spite of the announcement by the President that the discussion was closed, and persisted in addressing the meeting in a manner which resembled very much the touting of a cheap jack at a market fair. Of course, his remarks were greeted with roars of laughter by the audience; but, apart from their humorous aspect, such exhibitions have a reverse side which is painful and humiliating. No electrician who has the welfare of his society at heart can see with indifference the authority of the Chair set aside, and the effect of attempts to do so is distinctly demoralising. That this is the inevitable result was immediately made apparent, for when the President announced that the discussion would be continued at the next meeting one of the members, who is generally well known for his courtesy and tact, took it upon himself to direct the attention of the President to the question whether the author of the paper should at once reply to the discussion as far as it had gone, or should reserve his reply till the whole of the discussion had been completed. Can anybody imagine such a breach of etiquette to happen at the Civil Engineers'? I think not.

The existing state of affairs is not chargeable to the present President, for the evil has developed under successive presidents, and I remember one presidential address, some years ago, which, from its nature, was not open nor intended for discussion, being severely criticised by the very member of council who got up to move the customary vote of thanks. A president cannot be continually calling speakers to the point. Neither can he, as a rule, cut short any speaker who might dwell unduly on points of theory instead of bringing forward practical experience. Two hours every fortnight is a very short time in which to transact business, read papers and discuss them, and to save as much time as possible the order of speakers seems to be generally settled beforehand. The first speakers thus have practically *carte blanche* as to time, and generally abuse the privilege, so that subsequent speakers, although on the list, must compress their remarks too much to be of value, and those amongst the audience who have not had an opportunity of sending in their names are often debarred from speaking at all. This in itself is an evil, but it it is not all. The speech of inordinate length is almost sure to contain irrelevant matter, and if that be the case the temptation to criticise the discussion of the paper, instead of the paper itself, becomes very strong. The result is that previous speakers are in their turn tempted to interrupt the proceedings by defending their remarks or by explaining what they meant. All this could be avoided if every speaker would bear in mind that it is his duty to assist the president in making the discussion as good as possible, not only by the relevancy and scientific or practical value of his own remarks, but also by sitting down at the right moment.—Yours, &c.,

A MEMBER.

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SECONDARY BATTERY INDICATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : No reply having appeared to Mr. Elwell's letter on the above subject in your issue of the 19th March, I venture to say with reference to the suggested difficulty of maintaining the electrolyte at a constant level, that this is not a very difficult matter to ensure within practical limits on the part of the attendant by the ordinary means of filling up the cells with water to the proper mark as it evaporates; but, if desired to effect it with exactitude automatically, a simple method, which I know to have been adopted by Mr. Sellon, is to use an inverted flask or vessel, which, as occasion requires, is refilled with water and placed with its neck, or outlet tube, at the level which should be maintained. Displacement, of course, takes place in the vessel, and compensates for the loss by evaporation or other cause. One of the main objects of employing indicators is to prolong the life of the plates by ensuring proper limits of charge and discharge. It may be well, therefore, to consider the action of the apparatus described by Mr. Elwell relatively with Mr. Sellon's arrangement, described in your issue of March 12th.

In the first case, viz., Mr. Parker's device, which he states is not affected by alteration in the level of the electrolyte. By evaporation of water the solution becomes higher in density, and as a result his appartus cuts the cells out of the charging circuit *before they are fully charged*, allowing them also to remain in circuit *until they are overdischarged.*

In the second case, supposing no compensation is made as arranged for by Mr. Sellon, the increased density through evaporation of water would cause the apparatus to bring the cells into the charging circuit *before they were fully discharged*, also to allow them to remain in circuit until they were *slightly overcharged*—certainly the preferable alternative for keeping the cell in good working order. But, as I have already said, the maintenance of a constant level presents no difficulty, and no such variations need occur.—Yours, &c.,

March 29, 1886. HENRY A. KENT.

MISTAKES IN ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am much obliged to Mr. von Tunzelmann for his answer to my inquiry. It is the best and clearest answer I have got from any of those parties who believe in that which is called the theory of two electricities.

Mr. von Tunzelmann maintains that electricity is neither matter, nor force, nor energy. When two pith balls are electrified positively, they move from one another. According to Mr. von Tunzelmann's writings to you this event takes place according to "the law of electrical repulsion." Will Mr. von Tunzelmann be so good as to state wherein the repulsion resides ?

Again, when the two pith balls are electrified negatively they move from one another according to the same law of repulsion. Will Mr. von Tunzelmann state wherein the repulsion resides in this case also ?—Yours, &c.,

JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, 27th March, 1886.

THE ELECTRIC LIGHT AT MUNCASTER CASTLE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : In your notice of our installation of the electric light at Muncaster Castle in last week's number of *The Electrician*, you draw attention to some points respecting the positions of the lights in the rooms which we should like to offer some explanations upon. Owing to the Castle being in the hands of decorators and builders your representative did not see things quite in their usual state. The pillars which you mention in the hall or saloon are provided with large silk shades, which were then carefully stowed away and invisible, and they are not intended to light the room generally, but to be used as reading lamps to throw light upon lounges which stand under these pillar lights. We quite agree with your remarks respecting the dining room, and should have preferred to light this as we have lighted many similar dining rooms, from the ceiling, but a preference was expressed in favour of the older method of illumination by wax candles.

We do not think any advantage is gained by silvering the upper half of lamps placed over the billiard table. The lamps when in use are covered by the usual large paper shades, and these throw down the light in a more satisfactory manner than can be obtained by silvering the lamps. The latter method causes too much shadow to be thrown upon the cloth by the balls. We have tried many ways of lighting billiard tables, but have never found anything answer so well as the ordinary large paper shades, which require to be placed at exactly the correct height from the cloth to give an even light upon every portion of the table.—Yours, &c., J. EDMUNDSON AND CO.

19, Great George-street, Westminster, March, 31.

ARMATURE RESISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR : Will one of your able contributors kindly put me right on the following matter ? The resistance of an armature when running, and without reckoning the increased resistance due to heating, is usually reckoned at half the resistance of total length on armature, because the current divides at the negative brush and traverses each half, meeting at the positive. It appears to me that the resistance should be only one quarter, because virtually the two halves of the armature coils are in multiple or shunt. Suppose the bottom half of armature taken away, the current then would only have one path to traverse, and this being half the length of wire on the whole armature, will, consequently, be half the resistance; then adding the bottom half will open another path to the current of the same section and length as the upper, which reduces the whole running resistance to one quarter of the measured resistance of total length on A. If I am wrong in my reasoning I shall esteem it a favour if one more able than I will point out my error.—Yours, &c., DYNE-AMICABLE.

ELECTRIC LIGHTING AT THE LAW COURTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You will doubtless have seen paragraphs *re* the electric lighting at the Law Courts. Do you not think that the reporter who made the statement that the *screw passing through the top of the glass was too fine* has in some way got muddled ? I can scarcely credit that any electric engineer, let alone one entrusted with an installation like the Law Courts, should make such a statement. Consequently, if the reporter made a mistake of that kind I think others of his statements as to rheumatism, bronchitis, catarrh, &c., are equally misleading. At any rate, if the daily press wants to insert the reports of its correspondents, should it not assure itself by expert evidence that they have at least the *possibility* of being correct ?—Yours, &c., FAIRPLAY.

London, March 31, 1886.

ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 296.)

*General Considerations on these Theories.**

We shall now go on to discuss a general way of treating theories of the kind we have been considering. Perhaps the best way of doing this is to consider not the forces between the electrified bodies, but the energy possessed by them. If the energy depends on the electrification there will be forces between two electrified bodies. Now, the potential energy depends on the electrification, and this dependence produces the

* See Clausius "On the Employment of the Electrodynamic Potential for the Determination of the Ponderomotive and Electromotive Forces," *Phil. Mag.*, 1880, V. 10, p. 255.

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ordinary electrostatic forces between two electrified bodies at rest. If, however, the kinetic energy as well as the potential depends on the electrification, then the forces between two electrified bodies in motion will be different from the forces between the same bodies at rest. An easy way of seeing this is by means of Lagrange's equations.

If T be the kinetic energy, and x a co-ordinate of any kind, then we have, by Lagrange's equations,

$$\frac{d}{dt}\frac{d\mathrm{T}}{d\dot{x}} - \frac{dt}{dx} = \text{external force of type } x.$$

Hence if we have any term T′ in the expression for the kinetic energy, we may, if we like, regard it as producing a force equal to

$$-\frac{d}{dt}\frac{d\mathrm{T}'}{d\dot{x}} + \frac{d\mathrm{T}'}{dx}.$$

A simple illustration of this is afforded by the centrifugal force. In the expression for the kinetic energy of a moving particle there is the term

$$\tfrac{1}{2}mr^2\dot{\theta}^2,$$

where r is the distance of the particle from some fixed point, and θ the angle which the radius from this point to the particle makes with some fixed line; m is the mass of the particle. This term, by the above rule, will give rise to a force of type r, *i.e.*, along the radius vector equal to

$$mr\dot{\theta}^2,$$

and this is the ordinary centrifugal force.

Now let us consider a moving electrified body. If it is symmetrical, and moves in an isotropic dielectric, it is evident that the electrification, if it enters at all, can only enter as a factor of the total velocity q, and cannot affect the separate components of the velocity differently.

Let us suppose that the body is charged with a quantity of electricity denoted by e, then the kinetic energy, if it depends on the electrification, must be of the form

$$\tfrac{1}{2}mq^2 + f(e)\,q^2,$$

where $f(e)$ denotes some function of e. Now $f(e)$ must be always positive, for if it were negative we could make

$$\tfrac{1}{2}m + f(e)$$

negative, and then the electrified body would behave like one of negative mass. The simplest form satisfying this condition which we can take for $f(e)$ is αe^2, where α is some positive constant; so that the form of expression for the kinetic energy may be taken as

$$(\tfrac{1}{2}m + \alpha e^2)\,q^2.$$

Now let us go on to the case where we have two electrified bodies present, with charges e and e' of electricity; let m and m' be their masses, q, q' their velocities, of which the components parallel to the axes of x, y, z are (u, v, w), (u', v', w') respectively, the co-ordinates of the particles being (x, y, z), $(x', y' z')$.

If everything is symmetrical, the expression for the kinetic energy, if it only involves second powers of the charges of electricity, will be of the form

$$\tfrac{1}{2}mq^2 + \tfrac{1}{2}mq'^2 + \alpha e^2q^2 + \beta e'^2q'^2 + ee'\,\kappa\,.f\{u, v, w, u', v', w'\}$$

where $f(u, v, w, u', v', w')$ is a quadratic function of u, v, w, u', v', w'.

By Lagrange's equations we see that the last term will give rise to a force parallel to the axis of x on the particle whose charge is e equal to

$$\kappa ee'\left\{\frac{df}{dx} - \frac{d}{dt}\frac{df}{du}\right\},$$

with similar expressions for the forces parallel to y and z. We can see, by substituting in this expression, that we get Weber's law if we make

$$f = \frac{1}{r}\left\{\frac{x-x'}{r}(u-u') + \frac{y-y'}{r}(v-v') + \frac{z-z'}{r}(w-w')\right\}^2;$$

Riemann's law, if we make

$$f = \frac{1}{r}\{(u-u')^2 + (v-v')^2 + (w-w')^2\};$$

Clausius's law, if we make

$$f = \frac{1}{r}\{uu' + vv' + ww'\};$$

and that we cannot get Gauss's law in this way; this is in accordance with the fact that Gauss's law does not satisfy the principle of the conservation of energy. This way of considering the theories enables us to see that neither Weber's nor Riemann's formulæ can be right, for if they were, an electrified body, when in presence of another, would, under certain circumstances, behave as if its mass were negative. Thus take Weber's law as an example; let us suppose that two electrified bodies are moving along the line joining them, which we may take as the axis of x; then the expression for the kinetic energy, putting in the value of f, which corresponds to Weber's law, is

$$\tfrac{1}{2}mq^2 + \tfrac{1}{2}mq'^2 + \alpha e^2q^2 + \beta e'^2q'^2 + \frac{\kappa ee'}{r}\{q - q'\}^2,$$

so that if

$$\tfrac{1}{2}m + \alpha e^2 + \frac{\kappa ee'}{r}$$

be negative, then the coefficient of q^2 in the kinetic energy will be negative, and the body will behave as if its mass were negative; and, by sufficiently increasing e' or diminishing r, we can make this expression negative, so that Weber's law leads to results which are inconsistent with experience. This result of Weber's law was first pointed out by Helmholtz.*

Exactly the same objection applies to Riemann's theory, and indeed we see that it will apply to any theory which makes the force between two electrified bodies depend on *relative* velocities and accelerations.

(To be continued.)

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the meeting of this Society, on Thursday, 25th ult., Prof. HUGHES in the chair, it was announced, at the request of Dr. Stone, that tickets for his forthcoming Lumleian Lectures might be had of the Secretary of this Society, Mr. F. H. Webb, and that its members were invited to attend. The subject of the lectures would be "The Electrical Condition of the Human Body: the Body considered as an Electrolyte."

The following paper, on "Electrical Lighting by Means of Low Resistance Glow Lamps," was then read by the author, Mr. ALEXANDER BERNSTEIN, foreign member:—

It is not uncommon in the history of technical science to find that constructions which have at one time been abandoned on account of apparently insurmountable difficulties have, after a certain lapse of time, been re-adopted. The high-speed engine, the high-pressure boiler, the multiple telegraph system, were known and made long before they were generally applied, because their practical application was impossible until a certain amount of experience had been obtained by means of the low-speed steam engine, the low-pressure boiler, and the single telegraph system. In a very similar manner the low-resistance glow lamp was known and made more than thirty years ago, but has hitherto been considered impracticable. In the meantime the glow lamp of high resistance has made its way, and has met with considerable success. Now to-night I desire to revive the older type of lamps in a new form produced by means of our present experience, and to show at the same time the way in which these lamps may be made to answer the purpose of electric lighting.

As we have been so often told that the lamp of low resistance is neither practical nor economical, I must suppose that most electricians are somewhat prejudiced against it. But prejudices are detrimental to the development of truth, and I must therefore request you to take as impartial a view as possible of the case which I shall lay before you to-night. High or low resistance of glow lamps is not merely a question of construction of the lamp itself; it is a question of principle which determines the whole system of lighting. The requirements of the dynamo, the sizes of the conductor, and the whole system of arranging the circuit, are entirely dependent upon the lamp which we select. It is, therefore, not sufficient to compare different types of lamps in regard to their qualities as lamps; it is quite as essential to consider how the use of these lamps answers the practical purpose of electric lighting. I shall, therefore, divide my paper

* *Ueber die Theorie der Elektrodynamik.* "Crelle," Vol. LXXV., p. 535. Collected Works, Bd. 1, S. 647.

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into two parts—the first dealing with the lamp itself, the second with the manner of its application. In speaking of glow lamps, and considering their merits, I shall only take such lamps into consideration in which carbon is brought to a state of incandescence, and emits light by reason of its elevated temperature. Although other substances may be used, experience has shown so far that none of them offer the advantages which are secured by the use of carbon, viz., the possibility of applying a very high degree of temperature. This is very essential, because the highest temperature implies the greatest efficiency; and efficiency, together with durability, are the two qualities which principally determine the merit of an incandescent lamp.

Before proceeding any further, allow me briefly to enumerate the principal parts which constitute an incandescent lamp. These are only four—the glass bulb, the conducting wires (which always consist of platinum as far as they are surrounded by glass), the light-giving carbon, and the connection between the carbon and the wires (generally called the mounts). The simple construction of such a lamp does certainly not indicate that its manufacture is beset with so many difficulties. In order to settle our terminology, I shall further mention that the reciprocal of the number of watts required for every candle-power of light emitted will be called the "strain;" so that the strain is small if the number of watts per candle is comparatively large. The light which is emitted by incandescent carbon depends only upon its temperature and the amount of its radiating surface; but the energy which is required to maintain this light would be determined—irrespective of the losses which may occur in the lamp, and under the supposition that the state of vacuum and the exterior temperature remain unaltered—by those same two magnitudes alone, if the radiating power of all carbon were alike. It seems to me that this last is not the case. From certain analogies, well known in physical science, we may conclude that a black, sooty carbon will radiate more heat than a carbon of a dense greyish surface raised to the same temperature, and consequently the former will require a larger supply of electric energy to maintain it at the same temperature than the latter. This fact seems entirely borne out by observations made on glow lamps.

Let us now consider the peculiarities of a glow lamp of high resistance, say of 100 volts and 0·6 ampere. I select this lamp because it seems that this is approximately the highest resistance lamp which can be practically applied at the present time. At least, I can see no reason why the complicated expedient of a multiple-wire system should be used, if electric lamps can be made reliable when working at a much higher difference of potential and with a corresponding smaller current. As the lamp is only to take 0·6 ampere, the filament must be exceedingly fine in order to become sufficiently heated by this current, and, moreover, the filament must be of sufficient length to obtain the necessary amount of light-giving surface. As soon as the current is passed through the filament, the latter is raised to a certain state of incandescence; and we shall therefore have to deal first of all with the effect which heat alone seems to have upon the carbon. Heat has a general tendency to expand all substances; and as it was interesting to know how far carbon is subject to the same law, I have investigated this question by means of a lamp of the following construction:—Two straight filaments are connected by means of a crosspiece of platinum in the form of a T, which acts on a lever so arranged as to indicate ten times the elongation of the filaments when these are heated. The annexed sketch, in which A A are the filaments and B the indicating lever,

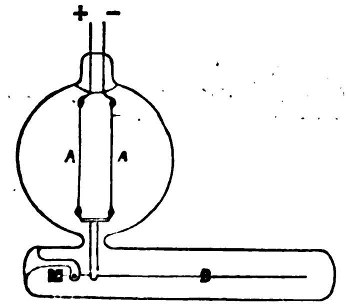

Fig. 1.

shows the arrangement which was adopted. The experiment indicated that when the carbon was exposed to a strain of 3 watts per candle, the elongation of the filaments amounted to 1-120th part of their length. It was further noticed that the rate of expansion was not constant, but increased with the temperature, although at the highest temperatures obtained the coefficient of expansion seemed to decrease again. The fact that the carbon expands and contracts with every change of temperature explains why lamps with slender filaments are destroyed more quickly when subjected to varying currents than when they are fed by a constant and uniform current, such as that supplied from batteries. When we look at a heated filament we notice sometimes that one small spot is brighter than the rest of the filament. This is an indication of a flaw which will sooner or later produce the disintegration of the carbon at this particular spot. These flaws are, for the most part, so minute that they cannot be perceived in the filament when cold, and only gradually show themselves when the lamp is being used. This is one of the causes which produce premature destruction of the lamp. The finer the filament the greater the danger of a flaw.

It has lately been supposed by some writers on the subject that the life of a glow lamp is in direct proportion to the diameter of the filament. Such suppositions, which are mostly made for the sake of obtaining mathematical formulæ, are far too sweeping; and all we are entitled to say is that, *cæteris paribus*, the lamp with a thick filament promises greater durability than the one with a thin filament. We have before observed that heat produces expansion of the carbon, and from this we may infer that if the heat is sufficiently high, evaporation or disintegration of the carbon would be the result. Such is the case if the carbon is of a soft quality, and raised to a very high degree of temperature; but we are fortunately in a position to produce a carbon of such dense and hard structure that there seems to be no perceptible disintegration at the temperature usually employed in incandescent lamps. If we, nevertheless, observe, in high-resistance lamps—even if worked at a strain of no more than 4 to 5 watts per candle, and a corresponding low temperature—that the carbon filaments are disintegrated, that the resistance of the lamps consequently increases, and that the glass bulbs begin to blacken, we are led to suppose that other forces must be at work which produce the destruction of the lamp. These forces are of an electrical nature, and their existence is easily explained if we consider that an electric glow lamp is at the same time a vacuum tube.

In the high-resistance lamp we have considered before, there is a difference of potential of 100 volts between the two terminals of this vacuum tube. The fact very soon makes itself apparent in the lamp. If the temperature is sufficiently high, the negative side of the carbon assumes a dark, sooty appearance, and a deposit of black loose carbon is formed on the positive platinum and mount. This action of throwing off particles of carbon from the negative side towards the positive has been the subject of a very interesting paper communicated to the Royal Society by Mr. Preece. The peculiar behaviour of high-resistance filaments is evidently the effect of a combined action of heat and electricity. The heat lessens the attraction of the particles for each other, and the electric forces produce motion. The result is the gradual deterioration and ultimate destruction of the carbon. It has often been noticed that a blue flame makes its appearance upon the positive platinum when the carbon is raised to a high state of incandescence. As no explanation of the production of this blue flame has as yet been given, I beg leave to insert here a few words respecting the most probable cause of it. All platinum, when cold, occludes a large quantity of oxygen, which is given off again when the platinum becomes heated. The black, sooty deposit of carbon on the positive platinum is just in a condition to combine readily with the oxygen, and both together form the blue flame. While the lamp is on the vacuum pump this flame may often be seen to travel up and down the platinum wire, always appearing where occluded oxygen is set free. If the pumping continues without the current being increased, the quantity of free oxygen is soon consumed, and the blue flame disappears, but reappears again if the temperature of the platinum is increased by increasing the current. Just in the same manner finished lamps will, under all normal conditions, show no blue flame, but will do so if an excessive current is passed through the lamp. In this case a blue flame is sometimes seen on the negative platinum as well. This occurs because particles of carbon find their way to the negative platinum and are oxidised there in the same manner. As the spectrum of the blue flame has been observed by Messrs. Liveing and Dewar to be that of carbonic oxide, it seems so much the more probable that the explanation here given is correct.

We have now to notice another effect of the vacuum tube. When lamps are made for very high difference of potential and corresponding small current, there seems to be a very strong tendency of the current to leap across from one terminal to another, thereby short-circuiting the lamp, destroying the filament, and fusing the platinum wires. This tendency is very strong when the current is turned on suddenly, as the carbon, being cold, then offers the highest resistance to the passage of the current. One of the conditions which it is desirable to observe in respect to a practicable lamp is that a certain excess of current such as is liable to occur in installations must not be able to destroy the lamp; and in this respect it is certain that the lamp with a thick filament is far superior to the lamp with a thin filament.

Turning to another point of practical importance, we notice the lamps with fine filaments are exceedingly subject to flickering as soon as the strength of the current varies but slightly. Variations of this kind may have their cause in irregular motive power, in slipping of a belt, or in a dynamo which is not perfectly balanced either mechanically or electrically. Such flickering will be noticed in a great many installations with small current lamps, and is exceedingly disagreeable to the eye. Now, with a large hollow carbon used in the lamp which I shall presently describe, the interior is always at a higher temperature than the exterior, and serves as a reservoir of heat which allows for certain variations in the current, without any effect on the eyes as regards the light. How are we, then, to obviate these difficulties appearing in the lamp? If the thin filament does not promise much durability, and is disadvantageous in other points mentioned—if the high difference of potential proves to be a factor in the destruction of the lamp—we must employ thick filaments and a small difference of potential; or, in other words, we must produce a low resistance lamp. I think I have sufficiently shown you the right of existence of a low resistance glow lamp, and I shall now proceed by describing the lamp which is before you, the form of which seems to be one of the best of all the varieties of low resistance lamps which I have made since 1882.

The lamp which is shown in Fig. 2 consists of a glass bulb of oval shape, into the opposite ends of which the platinum wires are sealed. In this manner the glass is placed symmetrically round each wire, and is therefore less liable to crack when heated. The carbon has the form of a straight tube mounted upon short pieces of stout platinum, which are joined to the platinum wires passing through the glass by means of flat thin copper strips, bent upon themselves so as to form springs at right angles to the direction of the carbon. In this way all parts of the lamp can expand and contract without subjecting the carbon to any injurious strain. A cap of insulating material at each end of the glass bulb provides for proper connection with the conducting wires, which may be made

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to support the lamp; and this connection is made in such a manner as to prevent accidental contact of the manipulator with any part carrying a current. The success of these lamps depends on the satisfactory construction of every one of its details in an almost equal

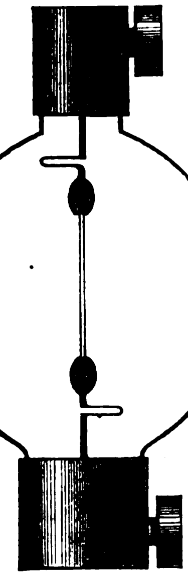

Fig. 2.

degree. The quality of the carbon, the way in which the same is mounted, the manner of surrounding the platinum wires with the proper kind of glass, the avoidance of any mechanical strain, and the proper proportion of every part of the lamp, are all the results of tedious experiments, which were necessary in order to produce a satisfactory lamp. The electrical dimensions of the lamp are as follow:—It requires a current of 9·75 amperes, thereby showing a difference of potential of 7 volts, and a hot resistance of about 0·7 ohm. When speaking of the high-resistance lamp, I have mentioned that there seems to be a limit to the difference of potential which we can apply in each bulb. As regards the low-resistance lamp, there is a limit to the strength of the current of which we can avail ourselves. The difficulty rests with the wires, which have to be sealed airtight into the glass, as it is far easier to seal in thin than thick wires carrying a large current. Before concluding this first part of my paper, I shall have to mention one of the drawbacks of the low-resistance lamps, to which Prof. Forbes has called attention in his excellent lectures on the distribution of electricity, viz., the loss of heat in the conductors inside the lamp. I quite agree with Prof. Forbes that in older types of lamps the loss was very considerable, and a serious question; but in the lamps which I made some years ago this loss amounted to only one-tenth part of the energy consumed. I am happy to inform you that in the lamp before you this loss has been reduced to one-twentieth part of the energy required in the lamp.

I shall now turn to the second part of my paper, and I consider it best to attack at once the most difficult problem which can present itself, viz., the supply of a large number of lamps from one central station, with the condition that all the lamps can be used entirely independent of each other, and with the further condition that the expenditure of mechanical energy shall always be proportioned, or, at all events, approximately proportioned, to the number of lights in use. Our imaginary plant is to be arranged for 6,000 lamps, requiring 9·75 amperes, and upon the average six volts each. Let us first look into the central station and consider its requirements. We shall settle upon the use of a dynamo which with a current of 10 amperes is capable of producing an E.M.F. of 2,000 volts—a kind of dynamo which was first applied by Mr. Brush, and which is already extensively used for arc lighting, or for a combination of arc lights with groups of glow lamps, several of the latter being always arranged in parallel. But the lamps of which I spoke at greater length in the first part of my paper are made for the passage of the whole current, and will therefore be arranged in series, one being placed in the line after the other. In this case there will be more than 300 lamps on each line; let us say 300. We shall, therefore, require 20 such dynamos, and one or two spare machines in case of repairs. These 20 dynamos may be driven from shafting, or each by a separate steam engine. There are 20 separate lines proceeding from the central station, and as the main condition of our system is that the current on every line must always be kept constant, we must provide for the regulation of each dynamo in such a manner that the E.M.F. always corresponds to the number of lamps which are in use. This regulation can be effected by automatic devices, or may be done by hand in adjusting the magnetic field or the speed of the dynamo. An ampere-meter which is placed in every circuit will indicate whether this condition is fulfilled, and a voltmeter connected with the terminals of each circuit will inform us how many lamps are used on each line at any time. A registering voltmeter placed in the same manner would be another useful addition. The central station, furthermore, contains a switch-board, which allows any one of the circuits to be connected with any one of the dynamos. If we presume that the station is to supply current day and night, it would certainly be absurd to run all the dynamos constantly at those times when only a small number of lights are required. At day time, then, I should propose to loop several circuits together, and if the total number of lamps is sufficiently low, all the 20 circuits might be looped in a single one, so that only one dynamo need be kept running. By means of an auxiliary line of lamps in the central station, dynamos and circuits may be switched in and out without any sudden change in the conditions of either. The system of working would then be that in the afternoon one dynamo after the other is switched into its respective circuit, the requirements of which can always be ascertained on the voltmeter of this circuit. If the consumption of light decreases, the dynamos are gradually switched out again. By the addition of an arrangement for observing and measuring the state of insulation of every line, the outfit of the central station might be considered complete. I have not mentioned any apparatus in connection with the central station which could not be easily constructed with the means at our disposal at the present time.

We now leave the central station, and turn our attention to the conductors. These are 20 pairs of copper wires of small size, say No. 6, well insulated. Experience has shown, so far, that there seems to be no great difficulty in insulating a wire if the tension of the current is not more than 2,000 volts. If we suppose that the central station is in Pimlico, on the banks of the Thames, a few wires may be laid in the direction of Victoria Station, a few more may reach the Houses of Parliament, some may be laid in the direction of South Kensington Museum, and some others may be used for lighting private houses—in each of which I shall suppose that, upon an average, 20 lights are used at the same time. In this case 15 houses are passed by the same conductor, which supplies current for 300 lamps. All these lights can be turned on or off at will, quite independent of each other, because we have provided in the central station that each dynamo is regulated in such a way as always to produce the same strength of current, no matter whether there are 300 lamps alight in each conductor, or only 10.

Let us now compare this system with the only other system in which glow lamps are arranged quite independent of each other, leaving out the consideration of secondary generators. In the parallel system the central station must be in the centre of the district to be lighted, which is often very objectionable, and sometimes impossible. In the series system the station may be far out of the way. In the parallel system we are restricted to the use of a 100-volt lamp, as we have seen before, and in consequence the radius of the district to be lighted must be kept very small, or the expenditure for conductors would be prohibitive. In the series system the expense for conductors is comparatively small, and we may reach any distance. The parallel system requires that a fixed difference of potential should be maintained in all the conductors under varying strength of current—a condition with which it is even theoretically impossible to comply, and which entails enormous practical difficulties. In the series system we have to maintain a constant current under varying resistances—a condition which can be easily fulfilled. When the parallel system was first developed, the prevailing idea appears to have been to make electric lighting from central stations similar to gas lighting. But the conditions under which electrical energy in its active form is best transmitted are so different from those requisite for the transmission of the potential energy of gas, that the desire to imitate the gas system has proved rather a disadvantage.

We now arrive at the last, and perhaps the most difficult, part of the whole installation, viz., the outfit of the place which is to be provided with lamps. For the sake of simplicity, I will suppose the place to consist of one single room, as shown in the sketch. In this sketch the small

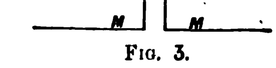

Fig. 3.

circles O, marked L, represent lamps; the squares [], marked S, represent switches (which will be presently described); and the cross +, marked V, is to indicate a registering voltmeter. The street main, M, enters the house at the main switch, drawn larger than the others; it continues from switch to switch, and returns to the main switch before leaving the house. We have supposed the street mains to be composed of No. 6 copper wire, but the house mains may be made equal in section to No. 10 wire, in order to be more flexible. The lamps are always connected to their respective switches. From what has been said before, it is quite evident that the first and essential condition of such a system must be that the circuit is never to be opened, whatever may happen. As we are always dealing with a closed circuit, it will prevent misunderstanding if we give a different designation to the two ways in which the circuit can be completed; and I shall therefore call the circuit "short-closed" if the current goes directly through the switch-lever, and "long-closed" if the current is led through the lamps or other electric devices, such as motors, which are to be acted upon. The fact that the circuit is never to be opened reduces one great difficulty in the switch required in the parallel system—viz., the liability to produce an arc. The main house switch, to which I shall now invite your

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attention, serves the purpose of either short-closing the street circuit, so that no current can pass into the house, or of long-closing the same, thus including the house circuit into the main circuit. In the first case I have not considered it sufficient merely to prevent the current from entering into the house; I have thought it advisable to disconnect the house circuit entirely from the street circuit at the same operation, so that any alteration of the circuit may be made inside the house without the possibility of a branch current being established, even if the street circuit should be of defective insulation. But this switch is also made to answer another purpose. Supposing that the street circuit which has been short-closed is now to be long-closed, but that by some accident or another a break of the continuity of the line has occurred in the meantime inside the house: if now the switch-lever were to be moved with the intention of allowing the current to enter the house, the result would be the formation of a long arc, and eventually the whole current would be interrupted. The manner in which this has been rendered impossible can be best explained by reference to the annexed sketch, in

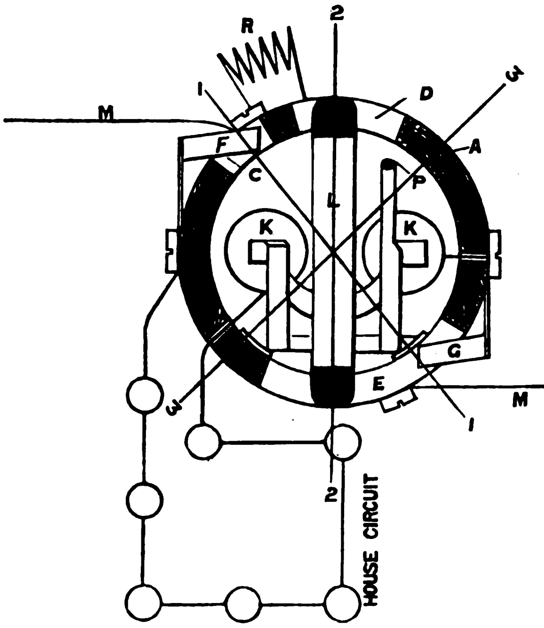

Fig. 4.

which A is the switch box, made of insulating material, and L the switch lever, made of conducting material. C, D, and E are three pieces of metal let into the upper edge of the circular box. The lever L may occupy three positions, marked 1, 2, and 3. In position 1, C is connected with E, and as C is one terminal of the main circuit and E the other, this circuit is now short closed. But if the lever L is in position 1, it lifts two flat springs of metal, F and G, which are the terminals of the house circuit, from their respective seats on the metal pieces C and E. The lever L carries on its upper side two pieces of insulating material, on which the two springs F and G now come to rest, and consequently the house circuit is out of all electrical connection with the main circuit. If it were now intended to allow the current to pass into the house circuit, the lever L would have to be turned from position 1 to position 3; but when the lever passes over the intermediate position, 2, it first connects the metal piece D with E. But the metal piece D is permanently connected with C by means of the resistance R, and the main current will therefore be divided in two parts—one, the greater portion, passing through R and L to E; the other, the smaller portion, passing through the house circuit in case the same is complete. This house circuit includes the electro-magnet K, which is situated inside the switch, and the armature of this electro-magnet carries a pin, P, which is in such a position that it is below the plane of the motion of the lever L if the armature be attracted, but hinders this motion if the armature be not attracted. In case, then, that the house circuit is complete, there will be no impediment to the further motion of the lever L from position 2. It will therefore reach position 3, where it rests upon pieces of insulating material, and the whole current now passes through the house circuit. But if the house circuit had not been completed, the motion of the lever would have been arrested by means of the pin P, and a break in the circuit is in this way made a matter of impossibility.

I shall pass at once to the lamp switch, because it is practically a mere repetition of the main switch on a smaller scale. But the lamp switch contains an additional arrangement, which would be a useful adjunct to the main switch as well, viz., the automatic cut-out. This is intended to act if the lamp should fail during the passage of the current, in which case the break of the current is prevented by short-closing it around the lamp. The arrangements which I have used to provide for this eventuality are of two kinds, and may be shortly described without reference to any drawing. Both are based on the principle that if the resistance of the lamp increases—which always occurs in lamps placed in series when the carbon gives out and an arc is formed—then a current in a shunt around the lamp will increase. In one of these arrangements this increased current is made to act upon the armature of an electro-magnet, which armature releases a spring for the purpose of making a direct secure contact between two places of the circuit in which the lamp is situated, and a short circuit is thereby formed round the lamp. In the other arrangement a fusible wire is placed in the shunt, and a lever is arranged in such a way as to be acted upon in one direction by the wire, and in the other by a strong spring. If the wire fuses, the spring presses the lever against contact pieces which serve the same purpose as specified above. In neither case can the circuit, which is now short-closed, be made to include the lamp again until the cut-out lever has been moved into its former position by hand. The combination between the switch and the cut-out lever is such that the switch-lever has to be placed into position 1 before the cut-out lever can be operated upon by hand. The reason for the adoption of this last arrangement will become evident by a consideration of the peculiarities of the switch, which I have mentioned before. I believe that in this way I have provided for the prevention of a break in the circuit which may occur from any eventuality. I need not dwell on the construction of the lampholder, the only part of the outfit which has not yet been mentioned. It may be made in different ways, but one principal idea has been adhered to in its design, as well as in that of all other details which constitute the outfit of a house; there is no part conveying a current which is not perfectly insulated, or which is in any way exposed so as to offer the possibility of any person coming into contact with it. This is hardly possible in arc light circuits, but may easily be done where only glow lamps are used.

And this brings me to the last question which I shall have to consider, namely, the question of safety. Here again I shall have to note one very great advantage of the series system over the parallel system, and this is the impossibility of a wire becoming overheated. Every experienced electrician knows a fact that short circuits in the parallel system have often led to detrimental results in spite of safety fuses; and a system in which such a danger does not exist, and which consequently does not require any provision against it, has certainly much to recommend it. Especially in such cases in which the danger of fire must be most dreaded—in ship lighting—I believe that this advantage of the series system will be very greatly appreciated.

I now come to the objection generally raised against the use of high-tension currents. If an inventor were to appear to-day saying he wanted to introduce into our houses a substance which, when properly used, was intended to give light, but which in itself was a poison, and produced poisons when used as a light, and of which it was further known that it was always ready to form an explosive agent when mixed with atmospheric air, I believe that the critical spirit of our time would raise an outcry against the introduction of such a dangerous substance, and against the use of the public streets for its conveyance. But this substance—of which we know that it is quite harmless as long as it is retained within the metal tubes—is now actually carried into all our houses, and we are so familiar with its peculiarities that no one feels any nervousness nowadays in the neighbourhood of a gas chandelier. In conveying a high-tension current into a house we are in a far more favourable position than if dealing with gas, because the probability of an accident is far more remote. Three conditions must be fulfilled before any person can be injured by an electric current. First, there must be a certain amount of leakage on the line; secondly, the person must be in contact with a bare conductor; and, thirdly, the person must at the same time be in contact with the ground. In the system of central lighting which I have laid before you it is easy enough to constantly ascertain the condition of the line, and far easier to locate a fault than in a complicated system of branch wires. It is, further, easy to construct all parts of the system inside a house in such a manner that contact with a bare conductor is impossible; and, moreover, a person standing on a carpet and a dry wooden floor is exceedingly well insulated. The tension which we can use with safety depends simply upon our means of insulation. If you will recall the precautions which have been taken in the construction of the switches by entirely disconnecting parts of the circuit from the main circuit, when lamps have to be replaced or alterations to be made in the circuit, then I think you will agree with me that the probability of an accident is exceedingly remote; and this system of lighting appears to offer more safety than any other method of artificial lighting at present in use.

And now, in conclusion, I should like to say that in a short paper like this which I have had the honour of reading to you, I found it impossible to enter more fully into details than I have done, and I have therefore restricted myself to the explanation of those details and the discussion of those questions which appear to me of prominent importance. I hope that by my humble efforts I may have accomplished the objects of my labours, namely, the further extension of the field of electric lighting.

The discussion on the above paper was opened by Mr. W. H. Preece, F.R.S., who complimented the author on having brought before the society an old subject with distinct originality. His experience of domestic electric lighting in his own house induced him to say that people who used gas in their homes had no conception of what life was like under the more wholesome conditions of electricity, and that anybody who, like Mr. Bernstein, endeavoured to bring it within the practical reach of the ordinary householder would do more good than an army of sanitary reformers. What was wanted, however, in his opinion, was cheap carbons and a cheap lamp—one that, whether it lasted only one hundred hours or as long as five hundred, could be thrown away and replaced without concern as to the cost.

Mr. Rawson pointed out some dangers which he apprehended would be incurred in changing Mr. Bernstein's pattern of lamp, and described the several risks from defects and mistakes appertaining to a system of this kind.

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Mr. Crompton stated that Mr. Swan had originally designed his lamps on a system of this kind, but that mainly owing to his (Mr. Crompton's) objections the idea was abandoned. He particularly feared the danger from accidental earth when using a constant current of high tension, and pointed out that the Board of Trade had forbidden its introduction into any dwelling house. He also thought the double mount of Mr. Bernstein's lamp (which was exhibited in action) was objectionable, especially when used as a pendant.

Prof. Forbes thought the expense of the switches was a great drawback, but on the other hand a vast saving would be effected in the conductors. On the whole he thought it the safest system of any, notwithstanding what had been urged to the contrary by Messrs. Rawson and Crompton.

Sir David Salomons gave his experience of glow lamps, which, as now manufactured, were of very long duration, and he preferred them to any cheaper form which would give out sooner.

Prof. Ayrton also expressed an opinion favourable to the safety of Mr. Bernstein's system ; and was sure it might be generally used for temporary installations with secondary batteries, comparatively few of which would be required to maintain the lights.

Prof. Silvanus Thompson approved of the constant current system, and pointed out that self-induction, which was our great difficulty with the prevailing system, would be actually advantageous in the plan here suggested.

The discussion was adjourned at a late hour.

LECTURE ON ELECTRIC LIGHTING.

Last week Mr. Alexander P. Trotter, B.A., A.M.I.C.E., gave the last lecture of the season to the Halifax Literary and Philosophical Society, describing the principle and development of lighting by electricity. Dr. S. C. Smith presided. Mr. Trotter had made elaborate preparation, and, by means of power supplied at his own works a short distance away, the place was illuminated by the lamps of various makers. As he acknowledged at the conclusion of the proceedings, he was indebted to Mr. L. J. Crossley for valuable assistance. The title of the lecture, as originally announced, was "Recent Improvements in Electric Lighting." Mr. Trotter explained that he conceived it in full expectation that the winter would bring as many improvements as previous years had done, but the season had been distinctly marked by the absence of changes. The lecturer proceeded to explain the principles of the dynamo machine, but for which electric lighting would have been a plaything, and which, but for electric lighting, must have remained a mere toy. After the performance of some interesting experiments with a very powerful magnet, he observed that the use of the expression "electric current" was more convenient than accurate. In the telegraphic message the effect was probably produced without the longitudinal motion of anything in the wire. The medium employed was probably identical with that which conveys light as air does sound. Another equally incorrect phrase was "electromotive force" — it was shortened to E.M.F., and was altogether an abomination. It reminded one of the French definition of the crab, which Cuvier pointed out would have been well enough but for the fact that the crab was not red, and was not an insect, and that it did not walk backwards. Electromotive force was not electromotive, and was not force. Mr. Trotter remarked, in passing, how, by the employment of such words as amperes, volts, watts, &c., eminent electricians were immortalised. He went on to show that there is no such thing as a perfect conductor, the degree of superiority being in the following order—silver, copper, iron, German silver, platinum. The great difference between copper and iron was strikingly demonstrated by a chain composed alternately of those metals. The heat was further exhibited in a novel fashion, viz., by toasting a piece of bread, about ¾ horse-power being expended. Proceeding to the examination of the incandescent light, the lecturer spoke in detail of the results attained by Swan, Edison, and other successful inventors, whose labours caused such a panic among holders of gas shares a while ago. It was pointed out that the relative merits of these systems were pretty well determined by the question of economy, the important consideration being the relative cost of different kinds of power. There was one recently improved lamp, but it was hardly before the public. It was his (Mr. Trotter's) privilege to introduce it for the first time that night. It was a useful and an artistic lamp. It was covered at the back with opal glass, and the front was clear, and the result was a beautiful, soft light, not nearly so dazzling as the generality. It was the invention of Mr. L. J. Crossley. An apparatus for exhausting the air having been perfected, they had now the electric light in an almost perfect vacuum ; that being so, the light would not set fire to anything if the lamp were broken, and there could be no possible danger even in a cotton mill. An arc light of 30 amperes was then shown. Mr. Trotter thought such lights would only be used for special purposes. Owing to the great pressure required, he was of opinion they were not likely to meet with as general favour, by reason of the increased danger to human life, as the incandescent system. He then turned his attention to the transmission of power, which he submitted was of much more importance than the production of the electric light. Electric motors were still in their infancy, but recent tests had shown that a good dynamo was almost invariably a good motor. The comparatively small amount of power obtained from steam was a disgrace to science ; the waste was enormous. But people were always looking for cheap power ; hence the proposals respecting the employment of wind and water for electrical purposes. Mr. Trotter gave an entertaining and instructive account of the tidal machinery, but he calculated that the required outlay upon appliances and civil engineering works was almost prohibitive. It was shown that with a ten-foot tide nearly two acres would be required for every continuous horse-power, and that to light 15 lamps a tidal basin, or reservoir, would have to be reclaimed from the sea of an extent of *three acres* ; but he recommended (though against his own interest) that, when ready, it would be a better investment to burn gas and *keep a cow*. A small motor in the room was set to work for a few moments in driving a lathe, with circular saw. The lecturer concluded with an example of light measuring through the instrumentality of a very simple photometer. Several low volt lamps were overrun, amongst others were some 30 volt 20 candle-power Woodhouse and Rawson lamps. The resistance was gradually reduced till they were subjected to 70 volts, when they emitted a beautiful light of nearly 300 candles for nearly a minute. The customary vote of thanks was spoken to by the chairman, Mr. J. B. Holroyde, and Dr. Bowman.

DOMESTIC ELECTRIC LIGHTING.*

BY W. H. PREECE, F.R.S., VICE-PRESIDENT OF THE SOCIETY.

(Concluded from page 395.)

Batteries.—No isolated installation is complete without a secondary battery. It maintains regularity and uniformity of current, so as to secure absolutely steady light. It supplies a reserve of power that renders one free from accident to engine or dynamo. It supplies a store of electricity that provides the householder with a source of light at all times and seasons. If you wake in the middle of the night, there is your light ; if you have to start by an early train, and dress before daylight, by the mere pressure of a button, you have your electric lamp alight ; if you have to breakfast on a dark, foggy, murky morning, you feed in soft daylight. The secondary battery has been much before the world. Its early failures disappointed many ; it was launched before the public at too early a stage of its infancy. It has sown its wild oats, but it is now a matured, sober, practical instrument. Sir William Thomson says :—"My cells have worked to perfection. It is the greatest possible comfort to us in the house to have the light, with satisfactorily equal brilliancy, at all hours of night and day, and every day in the week. I have now cut off the gas at the meter, so that there is absolutely none used in the house. I have no oil lamps, and have not used so much as a single quarter of a candle within the last three months, and have the electric light in every part of the house where light can possibly be wanted by night or by day." I can confirm every word of this. I have now had nearly two years' experience of them, and I would just as soon dispense with them as I would with my fireplaces or bedclothes.

Originally I used them as a regulator to my gas-engine, but I speedily found that it was more convenient and economical to charge them during the day, and discharge them through the lamps at night. In the depth of winter I charge them every day ; in late autumn and early spring three times a week ; and in summer I charge only once a week. It is very easy to know when the cells are fully charged. When the charging current is put on, the E.M.F. commences at about 2 volts per cell, and gradually rises to about 2·5 per cell. It acquires its maximum only when the cells are full. The current, on the contrary, falls. The density of the liquid, which is observed by a hydrometer floating in a cell, gradually rises, and when it becomes constant, the cell is full. Several hydrometers are used. Gas is then freely given off, and the cell has a milky appearance. On the other hand, when a cell discharges the hydrometer sinks, and when it reaches a minimum point it must be charged again. The E.M.F. also commences to fall when it is too empty, but I never allow that point to be reached. Good cells give an efficiency of 70 per cent. without losing E.M.F., and with a loss of 10 per cent. they will give over 80 per cent. The useful rate of a battery is the number of ampere hours it will give before losing 10 per cent. of its E.M.F. It is quite possible to get out of a battery all, or nearly all, the energy that we put in, but we cannot do so at a useful or economical rate. I give in the appendix a record of the charge and the discharge in my house in the month of February last, and also a record of last week's work.

The durability of these cells is most satisfactory. I see no reason why they should not last ten years at least. In fact, I believe the makers will maintain them at the rate of 10 per cent. per annum. The faults that I have experienced are very few and rare. Short circuiting from peeling or buckling are things of the past. I have never seen a case of "treeing." Occasionally the connections develop resistance and get

* Paper read at the Society of Arts, March 24, 1886.

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hot, but this is solely due to neglect; they require attention and cleanliness. It sometimes happens on high days or holidays that more current is wanted than can advisably be drawn from the cells; the engine is then allowed to run as well, but if the current developed by the dynamo is in excess of that used in the house, a few cells have to be taken off the battery, which is readily done by a switch, in order to maintain the E.M.F. in the house at its normal point. It is impossible, in fact, in the house to tell whether the engine is going or not. If it happens that the engine is kept continuously running, while the batteries are in action, special steps have then to be taken to prevent the cells from being irregularly charged, by changing the idle cells periodically.

A secondary battery acts perfectly as a regulator as long as its resistance is so small compared with the lamp circuit that it may be regarded as nothing, but if from any bad contact, fault, or weak cells, the resistance becomes appreciable, fluctuation in the light becomes evident, and it ceases to act efficiently. The latest form of cells are exhibited on the table, and they are now so well known that they need no description in this paper.*

Primary Batteries.—I have had no practical experience of their employment for domestic lighting, nor have I seen a house lighted up by them; but I believe there are several installations at work, and I am sure the Society will be glad to hear in the discussion some facts from those present.

Lamps.—No great progress can be chronicled in lamps like that in dynamos and secondary batteries. Their price remains very high. The ridiculous practice of giving lamps a fictitious nominal candle-power, which reached such a height of absurdity in arc lamps, and which was partially adopted with glow lamps, has nearly died out. Lamps which were called 20-candle lamps, are now sold as 16. The nomenclature of lamps is very illusory. The same lamp can be used to give 5, 10, 15 or 20 candles, according to the number of watts expended in it. A good standard glow lamp has not yet been devised. I should like to see a 10-candle lamp working under a pressure of 50 volts, and requiring half an ampere; that would mean the absorption of 25 watts, or 2½ watts per candle. Its life would not be very great at present, but if it were cheap enough, one would not mind frequent renewals. Since secondary cells are inseparable from isolated lighting, low E.M.F. means fewer cells, and therefore smaller capital expenditure, and small current means slow discharge. Ten-candle lamps are ample for domestic illumination; they lend themselves to better distribution of light. Two 10-candle lamps will give better illumination than one 20-candle lamp. My ideal lamp has not yet been placed in the market, though there are several approaches to it. There is a great variety of practice in determining the number of volts best adapted to work an installation. The conditions that regulate a central station system are quite different from those regulating domestic lighting The former requires high pressure to reduce the weight of the mains, the latter requires low pressure to reduce the number of cells. Both are governed by economical reasons. The Edison Swan Company adopt 100 volts; Sir William Thomson uses 85 volts; the Anglo-American Brush recommend 65 volts; the Electrical Power Storage Company, 60 volts; I recommend 50 volts for home lighting. I tried originally 31 volts, but I had to increase the pressure, for the low volt lamps took too much current from my cells. Makers of lamps seem to consider that there is great credit in securing long life. Unfortunately, glow lamps deteriorate sadly with age. The carbon wastes imperceptibly away, and we are scarcely conscious of the fact that, after 200 or 300 hours, the lamp gives only half the light it did at first. The fact is lamps last too long. I have been relegating my old lamps to the bed rooms, but they will not die, and I have been obliged to remove them "ere their time." The price of a lamp should be such that we can afford to give them a short and merry life. Long life is therefore an objection.

The efficiency of a lamp is generally taken to be the number of watts it consumes per candle per 1,000 hours of life; but a good measure of efficiency would be the number of hours it took to lose 10 per cent. of its normal light when absorbing 2½ watts per candle. Some interesting experiments were recently made in Berlin on this point by Mr. Wilhelm Siemens, who showed that in 800 hours an unflashed carbon, consuming 5 watts per candle, lost 37·7 per cent. of its light, falling from 19·9 candles to 11; while a flashed carbon, consuming 3·2 watts per candle, lost only 12·7 per cent., falling from 17·5 candles to 14·5. The resistance of the former increased 12·7 per cent., of the latter only 4·2 per cent. The process of flashing carbon is a process by which pure hard grey carbon is deposited upon the carbon filament by heat, decomposing some hydrocarbon gas with which the globe is filled. This deposit of carbon enables the filament to acquire a brighter surface, and attain a higher temperature before commencing to disintegrate, and therefore it gives a higher efficiency, for the amount of light given out depends simply upon the temperature.

A glow lamp, when incandesced, seems to lose its carbon mass steadily and regularly. The carbon molecules fly off, and are projected against the sides of the globe where they adhere, and cloud or discolour the glass; so that the light is diminished in two ways—first, by the wasting of the carbon, and, secondly, by its being deposited upon the glass, and preventing its radiation. The resistance increases owing to the diminution of the sectional area. This goes on until eventually, at some weak point, the mechanical strength is reduced to such a point that the filament becomes too weak to bear the slight strain upon it, and it breaks; or the density of the current becomes too high, and it dissipates away like a bright star, leaving a gap across the filament. This weak spot can often be detected by its brilliance before the lamp goes. There is a critical point in all lamps when a change of state occurs in the carbon filament. It is shown by the appearance of a beautiful blue effect pervading the whole globe. It occurs at some point between 1 and 2 watts per candle. It should be determined for each kind of lamp. I have an example of a lamp destroyed by lightning in Mr. Elwell's house, near Wolverhampton, which shows very beautifully the destructive effect on carbon of very high E.M.F. The globe is converted into a beautiful mirror. Lamps fail in giving their light occasionally from having an imperfect vacuum. This is very easily detected by feeling the globe. If the vacuum is bad it gets quite hot. Mr. J. T. Bottomley showed that a wire became red hot when the air was exhausted from the globe, though it was only 80 deg. C. when the air was in. Occasionally, but very rarely, lamps explode with a loud report when the current is first put on. This is, perhaps, due to a slight leakage of air making an explosive mixture with the residual gas. At the present moment, both the nomenclature and the efficiency of glow lamps are in a very unsatisfactory state, and we are buying pigs in a poke at a very high price. Mr. Edison adopted the very meritorious plan of determining the E.M.F. which would give his lamps a life of 1,000 hours, and the current that would give it the normal light. If this were done by every maker, it would be easy to determine the life at any other E.M.F., or the light at any other current, for the former varies with the twenty-fifth power of the E.M.F., and the latter with the sixth power of the current.

Considerable difference of opinion exists as to the character of the globe developing the carbon filament. Some like them clear, some like them ground; others envelope them in shades, generating light simply to choke it; while others, at a great loss, make the globe of a beautiful opal glass. It is very objectionable to have the optic nerve irritated by a brilliant glowing filament, but it is equally absurd to produce a good thing and then strangle it. Grounding and shading mean loss of light. Lamps can be placed so high that they need not affect the eye, and if they do the light can be so reflected as to be useful elsewhere. The art of lighting a room is to flood it with light without the delicate eye being offended with the direct rays from the source of light. An essential feature of a good lamp is a good holder, by which lamps can be readily removed and renewed. The platinum loops, which Mr. Swan originally introduced, proved very troublesome, through constant breakage. Edison's screw-holder was a much better, though more expensive thing; but Mr. Alfred Swan has recently introduced a "vitrite" holder, which embraces the merits of each, and leaves little to be desired. Switches to turn the lamps on and off are a source of great trouble in a house. As a rule they are cheap and nasty. When fixed away from the lamps they introduce into the circuit additional resistance, and therefore waste energy, but they are distinctly serviceable when they are fixed outside the door of a room, so that you can light it before you enter it. In many cases the lamp itself is its own switch, but it is objectionable to handle a lamp, and attempts have been made to utilise the weight of the lamp itself when suspended from the ceiling to maintain contact, and to break that contact when the weight is released. Cut-outs or safety-valves are essential to the security of a house. Short circuiting ought not to occur, but it does, and generally when showing off. It may occur when cleaning. The cut-out is so cheap, and so effective, that there is no excuse for its neglect. They should be fixed on every circuit.

Fittings.—The comfort and pleasure of a house depend upon its fittings. It is here that taste has its sway and art its swing, and the two are regulated only by the balance at the bank. It, however, fortunately happens that electric lighting does not lend itself to expensive fittings. The simpler they are the more effective. Sir David Salomons, who has spared no expense in obtaining energy at Broomhill, has exercised wise economy and rare taste in fixing his lamps. They are so suspended by their own conductors that in daylight you do not see them, but when darkness comes they spring into light like beautiful stars floating in the air. No one has taught us so much in this direction as Mr. Tayler-Smith, whose portable lamps and useful appliances were so much admired at the Healtheries, and at the Inventions last year. My house is full of them. I have lamps everywhere, and I can get light wherever and whenever I want it.

Wiring.—No one must imagine that electric lighting is absolutely safe from fire. It certainly possesses elements of danger, but elements that are perfectly under control. Several cases of fire have taken place, but invariably from crass ignorance. It is very simple to secure safety if the rules and regulations to avoid fire risks be carefully followed. The simplest rule is to use nothing but the best insulated wire, and to employ none but experienced men to put it up. All accidents that have occurred have arisen from careless wiring and ignorant handling. Wire has been ordered by so-called electrical engineers of such a quality that manufacturers have absolutely declined to supply it. Competition is so active, owing to the depression of business, that prices have been cut down so low that work can only be done at a profit by the use of poor stuff. In a new and growing business like electric lighting, competition should be very guardedly resorted to. There are firms of repute who are experts, and who can be trusted to carry out everything, but they are few. Protection should be procured by careful specification and constant supervision. The electrical engineer is as essential to the success of the building as the architect, and he should be engaged professionally. There is a great deal too much work done by the tradesman alone, and too little left to the expert. The design of the circuits of a house, the dimensions of conductors, the quality of materials used, the provision against fire risks, the testing of the work done, the adaptability of means to an end, should come within the province of the professional adviser, and not be left to the successful competing contractor, however eminent the firm may be.

Meters.—It is very desirable in a well-equipped house to see at a glance how many lamps are burning, how the dynamo is behaving itself, how

* Until January of this year I had been using Elwell-Parker cells at my house, but I am now trying the E.P.S. form, having removed the former to the Post Office.

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much current is going per hour into the battery, how much is coming out, and how well the electric pressure of the battery is maintained. Hence it is essential to have as good a voltmeter to measure the electric pressure in our circuits as to have a barometer to measure atmospheric pressure, or a thermometer to measure temperature or heat pressure. The most efficient, reliable, and simple that I know is Cardew's. Again, we must have a good current meter, and though amperemeters are thick as autumnal leaves in Vallombrosa, they are, as a rule, uncertain and misleading, especially with fluctuating currents. Siemens's electro-dynamometer remains master of the situation. Ferranti's meter is a most admirable adjunct. In my house one measures the current going into the batteries, and another measures the current going out, so that I am able to keep an accurate debtor and creditor account against my battery. The result for February is seen in the appendix. How far these meters are accurate within a wide range has yet to be determined. They are certainly more accurate than gas meters, and they are more easily comprehended. When electricity is laid on in a house it can be used for other purposes besides illumination. Mr. Sellon uses it for heating; a current of fresh warmed air passes through a coil at a temperature of about 180 deg. Fahr. and warms water-closets and dressing rooms. He uses it even for bed warming. I have used it for cigarette lighting, and it is frequently employed for driving sewing machines. I am now trying charming little portable lamps, worked by secondary cells, made by Mr. Pitkin, which enable me to visit my cellar with comfort.

Testing.—It is most desirable that every means should be adopted in a house to test the condition of the wires and apparatus constantly. Any incipient fault in a wire would speedily develop into a serious trouble under the influence of such powerful currents as electric lighting requires. It is, therefore, essential to detect its existence at once. All the circuits in my house concentrate in one place on each floor, and they are controlled by a switch. A current indicator, or galvanometer, wound with a thick and a fine wire. The former indicates the number of lamps burning, and checks improper lighting; the latter detects any leakage on the wires when the lamps are removed from their holders. There is also a galvanometer in the engine house. Secondary batteries facilitate testing. It is quite impossible for a leak to commence without its speedy detection, and if one were to appear, the particular circuit could be isolated at once by the switch. It is often said that it is all very well for me—an expert—to rejoice over the success of electric lighting in my own house. It would be a disgrace if it were not so, but there are non-experts who have been equally successful. Mr. Walter Palmer at Reading, Sir Thomas Bazley at Fairford, Mr. Coope at Berechurch Hall, Mr. Cortauld in Essex, the Rev. Sholto Douglas in Perthshire, Mr. Tate in Streatham, and many others, have had no trouble. In fact, when the work is well done, there should be no trouble. Its working is within the reach of ordinary intelligence. As regards cost, it comes out just twice that of gas; for, though I burn no more gas than I burnt before, I have more wages to pay; there are also repairs to machinery, and the purchase of oil and waste. The lighting of my home cost me, in 1885, £60. 0s. 6d.

	£	s.	d.
Gas	£34	9	0
Oil	2	5	0
Waste	0	12	0
Brushes	0	17	0
Repairs	4	9	6
Wages	10	8	0
Lamps	7	10	0
	£60	0	6

Now, if we charge against this the value of steady light, pure air, no heat, absence of matches, candles, and oil, comfort, durability of pictures, decorations, and books, no painters, cleanliness, cheerfulness, health, gain of time, long life, there is little doubt on which side the balance will appear.

The general distribution of electricity throughout extensive areas is a much larger question than that which I have attempted to deal with in this paper. I have endeavoured to confine myself to the past, and to the teachings of experience. The future of electric lighting in England rests very much with our Legislature, which, by the Act of 1882, has materially strengthened the monopoly of gas, by preventing the growth of a young and active competitor. There never has been one word said in favour of that Act, and it is monstrous that it should be allowed to remain on the Statutes without amendment. There seems some hope of something now being done

LEGAL.

The United Telephone Company (Limited) v. Bassano and Slater.

This action was brought by the plaintiffs against the defendants, Bassano and Slater, of Traffic-street, Derby, to restrain the infringement by them of a patent now vested in the plaintiff company, and the plaintiffs sought relief by way of injunction and damages. Shortly after the argument his Lordship gave judgment for the plaintiffs, and now stated as follows the reasons on which the judgment was founded :—

Mr. Justice NORTH: The letters patent bear date the 30th of July, 1877, and were granted to Mr. Thomas Alva Edison, a gentleman whose brilliant discoveries with respect to electricity have rendered his name famous throughout the scientific world, and they relate to improvements in instruments for controlling by sound the transmission of electric currents and the reproduction of corresponding sounds at a distance, or, in other words, to telephones. The letters patent contained at first thirty different claiming clauses, but these have by disclaimers at different times been reduced to one only. The defence put in originally in the action merely denied the infringement of the patent, but after issue joined the defendants, by leave, put in a further defence by which they set up that the invention, the subject of the patent, was not novel or useful, that Edison was not the first inventor, that the specification was insufficient, and that the invention had been published in this country before the date of the letters patent in twenty-one several publications. At the trial, however, most of these points were dropped, none of the alleged cases of anticipation was relied upon or gone into, the validity of Edison's patent was not substantially challenged, and three simple issues were raised by the defendants' counsel. The final clause of the specification, as last amended, now runs as follows :—"I would observe, in conclusion, that I do not claim generally the transmission and reproduction of sound by increasing and decreasing the resistance of the circuit, nor do I claim separately any of the parts or arrangements hereinbefore described and illustrated in the accompanying drawings except as hereinafter mentioned, but I claim as my invention—first, in an instrument for transmitting electric impulses by sound, the combination with a diaphragm or tympan of electric tension regulators, substantially as hereinbefore described, for varying the resistance in a closed circuit, substantially as set forth." The claim thus being for a combination of diaphragm or tympan with electric tension regulators, as and for the purposes described, the first two points raised by the defendants are—(1) that they have not used a diaphragm or tympan which falls within the specification; (2) that they have not used a tension regulator which is within the specification; and that therefore they have not taken either of the two things the combination of which alone is claimed. If the defendants succeeded on either of these points they would be entitled to judgment, but in case of failure on both they set up a third—viz., that Edison's invention is not commercially useful, having regard especially to the tension regulator portion of it, and that there is no evidence that any such tension regulator as he describes was in actual use. I do not stop to consider in detail the various discoveries and inventions, the improvements upon which are the subject of the letters patent now before me. It is sufficient to say that before the date of that patent it was known that if two similar plates or tympans capable of vibrating were placed a short distance apart, and were mechanically connected, the vibrations caused in one of them by speaking to it would be reproduced in the other, and this would in its turn cause pulsations in the air corresponding with those which made the first vibrate, and thereby reproduce articulate speech. It was also known that by the use of the electric current certain sounds, such as musical notes, could be transmitted to considerable distances, but no mode by which articulate speech could be reproduced at long distances had yet been worked out. The question for solution was—How can the pulsations of air caused by speech be made to operate upon a continuous electric current in such a manner that the current will reproduce vibrations or pulsations of air corresponding with those which first operated upon it? The mode in which Edison solved the question was by the use of a diaphragm to receive the pulsation of sound and operate correspondingly by causing variations of resistance in the electric current, and the arrangement by which this operation was accompanied was what he calls an "electric tension regulator." It is necessary, therefore, to consider these two things separately. But before doing this I should refer to the general description of his invention given by Mr. Edison in his letters patent. He says in his specification :—"This invention relates to that class of electrical instruments in which sound becomes one of the elements in the transmission of the communication and a corresponding sound is produced at the receiving station, so that oral communication can be sent by electricity and clearly distinguished at the receiving station. Musical tones may also be sent, but my present invention is specially available in transmitting and receiving oral communications. In transmitting musical tones the respective notes each has a definite period for each vibration, hence there is a response at the receiving end from the notes that vibrate in time with the electric pulsations sent; but in speaking there is little change in the musical tone, but considerable change in the modulations and inflections of the voice. In my present invention I make use of the vibrations given to a diaphragm or tympan by speaking into a resonant case to produce a rise and fall of electrical tension upon the line with such accuracy that the electric pulsations or waves will represent the atmospheric sound waves produced by articulation, and an electro-magnet at the receiving station will respond to the electric waves in such a manner as to reproduce the articulation by acting upon a resonant plate. The transmitting instrument in a complete form is represented in sections in Figure 1, and Figure 2 represents a receiving instrument which may be employed with it. Referring to Figure 1, the resonant tube or box A is of a size and shape adapted to being spoken into, the same having an opening at one end or side and a diaphragm or diaphragms, B, against which the sound waves from the human voice act, and these and the motion that the diaphragm receives are the means of producing the rise and fall of electric tension on the line by the devices hereafter set forth, so that the battery B, connected to the line C, will transmit a greater or less current to the distant electromagnet in Figure 2, and increase or lessen the magnetism of the cores, and in so doing act upon a resonant plate c, and develop sound corresponding to the articulation at the transmitting station. The general features thus described pervade my entire invention, but, in developing the same, many useful and important modifications and variations have been made which I will proceed to set forth." After referring to some details which are not of importance for the present purpose, the inventor proceeds as follows :—"The next feature requiring consideration is the character of the diaphragm in the speaking instrument. Many materials have been used by me, such as metals, horn, vellum, celluloid, ivory, &c., but almost all of them pro-

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duce a prolonged or second vibration from their own resonant character, hence the articulation is defective and the sound vibrations blend." His Lordship read a further extract, in which the inventor states his preference for mica, and continued: He then gives certain details with reference to his tension regulator, which I pass by for the present with the observation that he then refers to a diaphragm "covered with plumbago," which differs somewhat from what he had previously described. He then proceeds as follows:—"I sometimes perforate the diaphragm 10, Fig. 18, and place a strip of elastic material, 40, across the said diaphragm over the hole, and upon this a piece of foil, so that the same responds to every weak vibration, and in some cases two or more diaphragms are provided at different sides of the resonant box, each with its own tension regulator, the diaphragms being either the same, or of different sizes, characters, or tensions, so as to respond to varying sounds or acoustic conditions, the various tension regulators being all in the electric circuit (line 18). This will produce greater rise and fall of tension for longer lines in consequence of the diaphragms acting simultaneously on the tension regulators." In another passage he describes a totally different arrangement for a diaphragm. "A plate supported excentrically and free at its edges when placed in the speaking tube responds advantageously to the tones of the voice; the circuit with this plate is completed through one or more tension regulators placed round its edges." In that passage the inventor does not use the phrase "diaphragm, or tympan" at all; but it is clear that he is there referring to one form of the arrangement which is elsewhere indicated by that name. From these various extracts from the specification it is obvious that Mr Edison does not confine himself to one kind of diaphragm. It is clearly pointed out that diaphragms may vary in number, and may be one, two, or more. When more than one in number they may be of the same or different sizes, characters, or tensions; they may vary in position and may be at the ends or sides or wholly or partially across the instrument, or one may be mounted upon a perforation in another. They may differ in material, though the inventor gives reasons for preferring mica, and they may be set up in different ways, for they may be strained if constructed of a membranous material like vellum, which requires straining; or if the material, like mica, does not require to be strained, the diaphragm may either be secured at its edges, or it may be supported excentrically with the edges free. The specification frequently refers to a diaphragm or tympan as though they were synonymous terms, and an argument is founded upon this that nothing could be a diaphragm within the meaning of Edison's specification unless it were more or less a tympan or drum-head also, and it was said that nothing of that character was found in the defendants' instruments. Mr. Conrad Cooke, in particular, made a strong point of this. But I agree entirely with the opinion of Lord Justice Fry that the diaphragm described is susceptible to vibration produced by the voice, and this is common to a tympan also; and I do not think that calling it a tympan means more than this. And even if it could be said that in some form Edison's diaphragm was not a tympan at all, I do not think it material that a thing is called by an inapt name when I find the thing itself described with sufficient fulness and clearness for all practical purposes—as is the case here. The next point is as to what is the diaphragm referred to in this specific case. The ordinary meaning of the word is a partition or separation; and in the present specification I think it clearly means something which is capable of vibrating, and which divides the air on one side of it so as to allow of differences of air pressure on the two sides which produce the necessary vibrations of the diaphragm. It is proved to be quite immaterial on which side of the diaphragm the tension regulator is placed, and therefore it is not in any way essential that the diaphragm should separate one portion of the instrument from another part of it. In point of fact one form of instrument shown in Edison's specification has a tension regulator on the side of the diaphragm on which the speaker is. I have read from the specification Edison's description of the object of the diaphragm; and the witnesses on both sides concur in the view that its function, as indicated throughout that specification, is to receive and take up the air-waves and pulsations of sound produced by the voice and vibrate in accordance with them, and thus produce a varying or changing pressure upon the tension regulator resulting in a varying use of all in the electrical resistance of the circuit which, the specification points out, must be closed, and further that the form or shape of the instrument which thus gathers up the air-waves is immaterial except in degree. I think the evidence of the defendants' witnesses, Prof. Forbes and Mr. Conrad Cooke, when subjected to a little pressure in cross-examination, quite as clear upon their points as that of the eminent witnesses called for the plaintiffs. It is necessary now to consider the form of the instrument the defendants have made and sold. It consists of a conical hollow mouthpiece made of thin black wood, into the open, larger end of which the voice of the speaker passes. Towards the lower end of the cone the wooden part suddenly becomes larger and forms what has been distinguished as the black base. Within this is a cylindrical chamber into which the smaller end of the cone opens, and which chamber is of considerably larger diameter than such opening. To the sides of this chamber two points or blocks of hard carbon are firmly fixed, and a pencil of similar carbon with attenuated points is supported at its ends by each pair of blocks, the points resting lightly in a larger cavity in each of the supporting blocks and being in what has been called "loose contact" with them. The other end of this cylindrical chamber in the black base is then closed by its being fastened firmly to a piece of red stained wood, which is the portion of the instrument furthest from the speaker's voice, and has been called for distinction the "red back." The carbon blocks and pencils form the defendants' tension regulator, about which I shall have to say more presently, and they are connected in the usual manner with a line wire in a closed circuit, so that the electric current passes from one block to the other through the pencil which connects them. A portion of each pencil is opposite to the opening at the thinner end of the cone, and is visible through it. When the black cone is spoken into, the tension regulator is affected in such a manner that articulate speech is reproduced at the receiving end of the closed circuit, and the question is whether the means by which such result is obtained are protected by the plaintiffs' patent. It appears quite clear to me that the use of the red back is the use of a diaphragm within the meaning of that patent. The arrangement of the black cone and base, the red back, and the tension regulator are substantially the same thing as the transmitting instrument fully described in Mr. Edison's patent, except that the tension regulator is on the nearer instead of the further side of the diaphragm, which is represented in the defendants' instrument by the red back, and this variation of its position is admitted to be of no importance. Indeed, it is proved that when the pulsations of air caused by the voice are made to strike upon the back or outside of the red back the defendants' instrument speaks quite as well as, and under some circumstances better than it does when the voice speaks into the mouthpiece in the ordinary way. It is true that in the defendants' instrument the diaphragm is made of wood, which is not mentioned by Mr. Edison as one of his materials, and the use of which substance as a diaphragm is said to have some disadvantages. But a patent cannot be infringed with impunity by the adoption of an inferior material for a given purpose in lieu of a more efficacious article indicated by the patent for the same purpose, and it is obvious from the use of other instruments, and from the defendants' own instrument, that wood will answer very well for the purpose of a diaphragm. It is not necessary for me, for the purposes of my judgment, to say more than that by the use of the instrument of which the red back forms a part the defendants have used a diaphragm within the meaning of the plaintiffs' patent. But it has been clearly proved that if the red back is taken away the rest of the defendants' instrument still operates as a good telephonic transmitter; and the question whether any combination in which the black wooden portion of the instrument, consisting of the conical mouthpiece with its back base, or either of those parts, is included is protected or not has also been fully argued, and as I have considered it carefully and have formed a clear opinion upon it, and it may be important to the parties to know what my opinion is, with a view to subsequent action, I proceed to deal with it. I entertain no doubt that the use of the black part of the defendants' instrument, as well as the red back, is the use of a diaphragm within the meaning of Edison's specification. Each of those parts separates the air on one side of it from the air on its other side, and thus allows the differences of air pressure to exist on its opposite sides which render it susceptible of vibration, when the air-waves come in contact with it, and it gathers and takes up these sounds and vibrates in accordance with them and transmits them to a tension regulator. The experiments tried by Dr. Hopkinson, the details and results of which were fully explained by him, and were not challenged by the defendants, prove this to demonstration. The trials of the several portions of the defendants' instrument as parts of a telephone which acts solely by mechanical vibration were completely successful, and the instrument spoke perfectly. The defendants' counsel attempted to make out that the operation of the defendants' instrument was produced solely by the direct impact of the sound waves upon the pencils of carbon in the defendants' tension regulator, and that the vibration of the black cone and base and the red back had nothing to do with it. But this is quite inconsistent with the result of the experiments, and also with the proved facts that the defendants' instrument speaks better when the outside of the red back is addressed than when the voice enters the mouthpiece, and that it speaks quite as well when the aperture from the narrow end of the cone into the cylindrical chamber is closed by a cork; when the cone is continued down to the red back as in J H 2; when the pencils are moved further apart in the cylindrical chamber, so as to be sheltered from the direct action of the voice, as in J H 3; and when the outside of the black cone is spoken to, as in its normal condition. In fact there is no real conflict of evidence upon the question whether these portions of the defendants' instrument performed the functions of the diaphragm as such functions are described in the plaintiffs' specification. The defendants' witnesses, when pressed in cross-examination, confirm the direct evidence of the plaintiffs' witnesses. The defendant Bassano says that these portions of his instrument are really for a totally different purpose; that the function, or main function, of the black cone is to concentrate the air-waves from the voice on the tension regulator; that the black base is to hold the carbon-blocks which support the pencils, and that the red back is merely a support for the rest of the arrangement. But even if this be so, yet if they discharge the function of the plaintiffs' diaphragm they are none the less an infringement. But the most important contention on the part of the defendants is that, even if the above-mentioned parts of their instrument so perform the functions described, still they do not come within Edison's specification. In other words, they attempt to circumscribe the area of that specification and limit it to particular kinds of diaphragms and tension regulators as much as possible. This is clearly shown in the answers of the defendant Bassano to his counsel's question whether he considered the black cone or base, or the red back, to be diaphragms, to which he replied, not by a simple negative, but by saying he did not consider them diaphragms according to the specification of Edison, and the other witnesses for the defence take the same line. So, too, the defendants' counsel press upon us that Edison's diaphragm is a distinct portion of instrument figured in his illustrations, distinguished by a letter, and shown in particular positions, and also further identified as being made of mica as the material preferred, and being in every one of these points something quite different from the parts used by the defendants which are said to be infringements. But I have already pointed out that the specification is not confined to one special form of diaphragm. On the contrary, it describes diaphragms differing in size, number, material, form, position, and otherwise, though the common function they are to perform is clearly shown. Under these circumstances it is impossible for me to hold that the patentee is limited to any special form. Indeed, his claim

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is the combination of a tension regulator with a "diaphragm or tympan," not confining it to any special form, and I have heard no complaint that the claim is too large in this respect. The contention of the defendants appears to me incapable of being maintained, either upon principle or authority. As regards principle the patentee discovered a very remarkable new manufacture, and described its essential conditions, and pointed out how it was to be performed, and indicated several practical modes of carrying it into effect, and the law does not require him to describe every way of carrying it out, or limit the protection it confers to the modes particularly described. If the defendants place a diaphragm in their apparatus which performs the functions of the diaphragm in the plaintiff's apparatus, they cannot escape the charge of infringement by making a non-essential variation in the position or form of the diaphragm material. And, as regards authority, the decision of Lord Justice Fry in the case he decided seems to me to cover the present case. In the specification and drawings of the plaintiffs' patent the diaphragm is always referred to by the letter B, and this is made to operate by its vibration on an electric tension regulator in physical, but not necessarily in mechanical, connection with it. The regulator first described is of compressible bunches or tufts of elastic fibre, forming part of the circuit connected either by a diaphragm spring or secured by solder, or by a delicate cork centre-piece, or with a piece of platinum foil, *x*, in contact with the fibre; in all instances the telegraphic circuit being made by a thin strip of platinum or similar material extending to the centre from the line or battery connection. In that case it is quite clear that the piece of platinum foil is not described as part of the diaphragm nor exposed to the air-waves, though no doubt it is affected by the vibrations of the diaphragm through the cork or the spring; but is described as part of the tension regulator, and actually forms an essential part of the electric circuit. The alleged infringement before the Court on that occasion was Hunning's transmitter. His lordship discussed that case and continued: It was also said by the defendants that their instrument does not require anything in the nature of a diaphragm, that it will act perfectly without, and, therefore, that it cannot be an infringement of Edison's combination. And they appeal to the experiments made with carbon blocks and pencils. Those made by the defendants' witnesses were successful to some extent; those by Sir William Thomson did not answer so as to produce articulate speech. It is obvious that there is still room for further investigation in this direction, but the question whether the defendants could dispense with a diaphragm or not is not now before me for decision. As a matter of fact they never have done so, for they have never used thin carbon blocks and pencils in practice except in combination with the cone, the black base, and the red back, each of which, as the defendants' witnesses admit, does assist, by intercepting the sound waves vibrating synchronously with them, and so acting on the tension regulator, and they have, therefore, adopted Edison's combination unless the tension regulator they have used is outside his specification, the point I now proceed to consider. The electric tension regulator of the Edison specification is the apparatus forming a joint or link in a closed circuit, by which the vibrations of the diaphragm are made to produce a rise and fall in the electric current passing along the line wire by varying the amount of resistance, such variation being caused by increasing or diminishing, by the change of pressure, the area of surface contact within the regulator. In a passage in the specification which I have already read, Edison says that the motion of the diaphragm is the means of producing a rise and fall of electric tension on the line by the devices hereafter set forth. He also says:—"I find it is not practicable to open and close the line circuit in instruments for transmitting the human voice; the circuit to the line must be always closed, and the transmission be produced by a rise and fall of electric tension resulting from more or less resistance in the line. This resistance may be produced in several ways. I have shown several which will hereafter be named, but I find the most delicate to be small bunches and tufts or discs of semi-conducting fibre, such as particles of silk, and an intermediate conducting or semi-conducting material; this device I call an electric tension regulator; it more or less compressed according to the vibrations of the diaphragm or tympan, and the electric current rises in tension as it is compressed, or lessens as the fibre expands." He also describes an arrangement, shown in Figure 10, in which the diaphragm is placed at the end of a resonant chamber, and has at each side of it springs with points made of compressed plumbago, mixed preferably with gum or any substance not liable to rapid decomposition, or the "elastic or fibrous tension regulator aforesaid may be used." And after pointing out how this operates to vary the current by creating greater pressure upon the plumbago points on the two sides alternately, he says that, as the tension regulator of fibre or plumbago decreases and increases its resistance enormously under slight changes of pressure, it follows that the strength of the electric waves will be in proportion as the speaker's voice is strong or weak. A little further on he speaks of another arrangement by which a plumbago contact point is so arranged as to present a semi-rigid point for contact, so as to prevent a rebound and allow of a slight yield when the plumbago is pressed by the diaphragm. [His lordship further referred to the specification, and continued]: It appears clear to me, as it did to Lord Justice Fry and Lord M'Laren, that Mr. Edison did not attempt to describe every form of tension regulator to be used with instruments made under his specification; but Lord Justice Fry pointed out that the regulators he describes have three essential properties—(1) that of compressibility, in order that the area of surface contact may be capable of being increased by pressure, and the resistance to the current diminished accordingly; (2) that of resiliency, either from the natural elasticity of the substance employed or produced by artificial means, so that when the pressure is removed the material may return to its normal position, and thus check the current, which had been increased by its compression, and be in a position to repeat the operation time after time; and (3) that of semi-conductibility. In the present case the scientific witnesses on both sides agree that these three qualities must be found in Edison's tension regulator. The question then is whether the hard pencil carbon used by the defendants in their instrument, as I have explained, comes within the description of "electric tension regulators substantially as hereinbefore described," as used in Edison's specification. The plaintiffs' witnesses say that it does, for that it is semi-conductive, compressible, and resilient. The defendants' witnesses say that it does not, for it is not semi-conductive, not compressible, and therefore not resilient. And yet, when the evidence is considered attentively, there is very little, if any, difference between them after all. It is merely a question of degree. [His lordship discussed the evidence and continued]: It is also said that even if the defendants' hard carbon blocks and pencils have the attributes of Edison's tension regulators, a regulator of hard carbon is quite a different thing from any described in the specification. [His lordship stated his grounds for differing from this view, and referred to the straightforward way in which the defendant Bassano had given his evidence, and continued]: I am of opinion that the defendants' instrument is like Edison's, a combination of a diaphragm or diaphragms vibrated by the voice with an electric tension regulator consisting of a semi-conductive compressible, and resilient substance for varying the resistance of the electric current in a closed circuit, and that it is within the scope of and an infringement of Edison's specification. His lordship then shortly disposed of the point that Edison's invention was not commercially useful, and read the evidence of Sir William Thomson and Prof. Forbes to show that it was, and said that on this point also the defendants failed.

Sir R. Webster, Q.C., Mr. Aston, Q.C., Mr. Moulton, Q.C., and Mr. Micklem were for the plaintiffs; Mr. Bigham, Q.C., and Mr. Plumptre for the defendants.

Varley's Electric Plant Company.

In the Chancery Division of the High Court of Justice, on Thursday, before Vice-Chancellor Bacon, Mr. Ford made an *ex parte* application for the appointment of a receiver of Varley's Electric Plant Company (Limited). The application was made on behalf of Mr. Barber, a debenture holder. The interest upon the debentures became due on Wednesday, and when Mr. Barber applied for it he learned that the company was insolvent; that a resolution had been passed to wind up; that the two principal officers, the managing director and the secretary, had commenced actions to recover the amount of their salaries; and that on Wednesday, with the assent of the company, certain of their effects were seized and sold in order to pay off those claims. Under these circumstances, in order to protect the remaining assets, the debenture-holders, in the name of Mr. Barber, had commenced this action.

The Vice-Chancellor appointed a receiver, as asked.

COMPANIES' MEETINGS.

Western Counties and South Wales Telephone Company (Limited).

The first annual ordinary general meeting of the Western Counties and South Wales Telephone Company (Limited) was held on March 25th at the Grand Hotel, Broad-street, Bristol, Mr. C. Nash, Chairman of the Board of Directors, presiding. There was a very limited attendance of shareholders.

Mr. H. F. Lewis, general manager and secretary, having read the notice convening the meeting, the report, which had been printed and circulated amongst the shareholders, was taken as read.

The following are the principal features of the report:—Capital Expenditure—Reference to the capital account will show that up to the 31st December, 1885, a sum of £29,352. 16s. 1d. has been expended in the company's district; this includes the sum of £14,500 paid to the United Telephone Company. Revenue—The revenue of the Company up to the same date has been £8,729. 14s. 7d. Working Expenses—The working expenses, exclusive of royalties, for the same period have been £4,917. 5s. 2d. Preliminary Expenses—It will be observed that these have been moderate, considering the magnitude of the business dealt with, and the directors have decided to spread them over a period of five years. Maintenance—The Company's plant has been maintained and renewed out of revenue. Reserve Fund—The directors propose to place the sum of £500 to a special reserve fund, against depreciation of plant, &c. Dividend—The balance of nett revenue account is £2,327. 0s. 1d., which, after deducting the £500 proposed to be placed to the special reserve fund, and the payment of a dividend of six per cent. on the paid-up preference share capital to the 31st December, 1885, £894. 17s. 9d., leaves a balance of £932. 2s. 4d. to be carried forward to next year. Preference Capital—The directors have pleasure in saying that the first issue of 10,000 £5 preference shares has been allotted. Ordinary Capital — 25,000 ordinary shares remain in the hands of the directors to deal with in such manner as they may deem desirable for the benefit of the Company. Progress of Business—This is shown by the following figures. The number of subscribers to the various exchanges and the number of private line renters on the 31st August, 1884, and on the 31st December, 1885, were as follows:—

	Exchange Subscribers.	Private Line Renters.
December 31st, 1885	494	239
August 31st, 1884	308	171
Increase	186	68

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Exchange Business—Exchanges have been opened at Bristol, Clifton, Cardiff, Newport, Plymouth, Devonport, Mutley, Torquay, and Portsmouth. Since the 31st December the Company have opened their exchange system in Bournemouth, and it is their intention to open exchanges at Aberdare, Bath, Gloucester, Great Malvern, Hereford, Llanelly, Merthyr, Neath, Pontypool, Pontypridd, Southampton, Swansea, Sharpness Docks, Weymouth, Worcester, Weston-super-Mare, and at all other places in their district where they find sufficient support. United Telephone Company—The Directors have pleasure in stating that the Company are working in perfect accord with the United Telephone Company. The accounts between the companies in connection with the transfer of the business have been satisfactorily settled. The United Telephone Company have successfully defended their master patent rights against various infringers in the Company's district.

The CHAIRMAN, in moving that the report and audited accounts be adopted, observed that though that was the first annual meeting of their local telephone company, the accounts comprised 16 months' work—that was to say, from the 1st of September, 1884, to the 31st of December, 1885. The date of holding the meeting was somewhat later than intended, some delay having arisen in consequence of the accounts being a little complicated at first. He hoped that on the whole the shareholders would consider that the result of the working had been satisfactory. He was not going to dwell on the figures, for he thought that the accounts put them very clearly, and scarcely required any explanation. Great care had been taken to charge the revenue with everything applicable to revenue, and that point was particularly noticed by the auditors, who spoke favourably on it, and in the way the stock account was kept. Mr. Lewis was, in fact, complimented on the stock account being kept in a more complete way than almost any others which the auditors had met with in their experience. One-fifth of the preliminary expenses, and one-tenth of the cost of the furniture had been written off, and they proposed to begin a reserve fund against depreciation of plant by setting aside £500. So much for the accounts, and turning to the future he thought they might all of them be reminded that the telephone in this country was quite in its infancy. In England they had about 32,000 telephones, whereas in America there were 325,000. Some people imagined that the great spread in America was because the rates were lower, but in New York the rate appeared to be £30 and upwards, whilst in Bristol it was £15, and the highest rate in Great Britain was £20 a year. In most of the large towns in America the charge was £25, but in New York alone there were more telephones than in the whole of the United Kingdom. He thought they might fairly assume that gradually, and perhaps rapidly, the telephone would increase in use in their own country. In Bristol there had been a steady progress, and if they looked at other places in their district they found that Plymouth and Torquay were likely to afford a considerable increase in their business. They had opened an exchange at Bournemouth, which had commenced in a most satisfactory manner. At once there were about fifty subscribers, and they looked forward confidently to having at least 100. Mr. Lewis, the secretary, was present, and looking over the report of the proceedings he (the Chairman) observed that they looked upon him there almost as a public benefactor. They were preparing to open exchanges at Bath, Gloucester, Sharpness, Weston-super-Mare, Worcester, Malvern, and many other places, but perhaps the most important part of their district was South Wales. Trunk lines were to be established—were, in fact, in progress between Bristol, Cardiff, Newport, Swansea, and Llanelly, and the Chairman pointed out that by an extension from Cardiff to Pontypool, and to the Rhondda Valley, Aberdare, and Merthyr, they hoped to have a network of wires to the various works and collieries in the neighbourhood. The Chairman said he would like to remind their friends of the great extent of district that the Western Counties and South Wales Telephone Company possessed. Looking at the extent of surface it was more than one-fourth of the whole of England and Wales. It was true there were not many large and populous towns, but there were a great many towns where they might look forward to a considerable telephone business. In Cornwall, he believed that the mining centre about Camborne was likely before very long to be an important telephone district for them. He observed that free communication had been given to their charitable institutions, and a few days ago Mr. Cave, the president of the Infirmary, mentioned how thankful the staff felt that telephonic communication with the Infirmary had been given. The advantage of the telephone system in case of fire had been proved over and over again, and only on Saturday last its usefulness to the police was shown in the case of a demonstration of the unemployed. Finding out what the route of the procession was likely to be the police were enabled to telephone to the various stations, so that a body of police could be placed on the line of route, and that could not have been done without the telephone. The Chairman then formally moved the adoption of the report and accounts, and the declaration of a dividend of 6 per cent. on the paid-up preference shares.

Mr. MARK WHITWILL seconded the motion, and said, like Mr. Nash, he believed that the use of the telephone was yet in its infancy. It was coming, however, to be regarded as one of the necessities of life, and nothing was likely to check its growth unless it was the obstruction of local authorities.

Mr. J. B. MORGAN (London) said that as one of the largest preference shareholders it was pleasing to him to observe that that was the first of the companies that had placed a sum to reserve account in the first year of its existence. That was highly gratifying, and though a director by nomination of the United Telephone Company (Limited), yet he was speaking from personal knowledge of telephone business all over the kingdom. After remarking that the amount of profit which that Company had made for year was very substantial, he said the United Telephone Company had made arrangements with three of the great railway companies to turn all their railway stations into telephone exchanges, and there was no reason why, by-and-bye, Bristol might not talk to London and every other station on the line of the Great Western.

Mr. BATTEN (also a director of the United Telephone Company) said he had taken a deep interest in the telephone enterprise, and was not a little disappointed that it had not progressed in England with the rapidity it had on the other side of the water. The speaker referred to his experience of the advantages of the telephone service in South America, and mentioned instances in which tradesmen found that to be upon the telephone exchange was of great service to them. During the recent riots in London the Telephone Company could have furnished the police authorities with 4,000 points of attack, and Mr. Morgan and himself being in the board room on the day in question were enabled to warn some of the banks.

The resolution was unanimously adopted.

On the motion of the CHAIRMAN, seconded by Mr. H. FEDDEN, it was resolved that a sum of £500 be placed to a special reserve fund for depreciation of plant.

Mr. Chas. Nash, Mr. Mark Whitwill, Commander Forsyth, R.N.; Mr. Henry Fedden, Mr. Thomas Pole, and Mr. Richard Cory were re-elected directors, and Messrs. Tribe, Clarke, and Co. were re-appointed auditors.

The CHAIRMAN said they had in Mr. Lewis, the secretary and manager, a most valuable officer, and he thought they should not leave without expressing the opinion they entertained of Mr. Lewis's services. He did not think they could possibly have a more efficient officer, and he moved that the best thanks of the shareholders be given him.

Mr. MORGAN, in seconding the resolution, said Mr. Lewis had worked under him before coming to Bristol, and he had pleasure in bearing testimony to his business capacity, and his manliness of character.

Mr. WHITWILL, in supporting the resolution, said he had never met with a man with quite so much zeal and energy as Mr. Lewis, and remarked that the Chairman and himself were accustomed to speak of him as the indefatigable.

Commander FORSYTH having also borne testimony to the value of Mr. Lewis's services,

The resolution was carried by acclamation.

Mr. LEWIS briefly acknowledged the resolution.

An extraordinary general meeting was then held for the purpose of making certain alterations in the Articles of Association, and resolutions approving the same were unanimously adopted.

A vote of thanks was passed to the Chairman, and the meeting terminated

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES	Closing Prices. March 31.		Business Done Week Ending March 31. Highest.	Lowest.
Anglo-American	36,	37	36⅜	36
Do. Preferred	60,	61	60¼	60⅜
Do. Deferred	12,	13	13¼	12½
Brazilian Submarine	11⅛,	11⅜	11 7-16	11 3-16xd
Cuba	10½,	11	—	—
Do. Preference	17½,	18½	—	—
Direct Spanish	1½,	2	1½	1⅜
Do. Preference	11	11½	—	—
Direct United States Cable	10,	10½	10	—
Eastern Telegraph	12,	12¼	12 5-16	12
Do. 6 per Cent. Preference	14⅛,	14⅜	14 5-16	—
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	13⅛,	13⅜	13⅜	13½
German Union	9½,	10	—	—
Globe Telegraph and Trust	7,	7¼	7 3-16	7 1-16
Do. Preference	13½,	13¾	13 11-16	13 7-16
Great Northern	14½,	15	14¾	14 11-16
Indo-European	37,	38	37½	—
Reuter's	6½,	6¾	7	6⅜
Submarine	200,	216	—	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	9½,	9¾	9 9-16	—
Western Brazilian	7⅜,	7⅝	7⅝	7 7-16
Western Union 7 per Cent. 1st Mortgage	117,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	15-16,	1 1-16	—	—
Oriental	¼,	⅜	—	—
United Telephone	12½,	12¾	12½	12½

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3⅛,	3⅜	3½	—
Do. (fully paid)	5,	5½	5½	—
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1¼,	1½	1 7-16	1⅜
Maxim-Weston	5-16,	7-16	—	—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37¼	36⅜
India Rubber, Gutta Percha, and Telegraph Works	23	24	23½	23

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NOTES.

West Indies.—The cables between St. Lucia and St. Vincent, and between Dominica and Guadeloupe are interrupted.

The West Coast of America Telegraph Company.—The gross earnings of this company for the month ending March 31st amounted to £3,525.

The Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 2nd April amounted to £3,076.

Uruguay.—The telegraph lines in Uruguay are many of them interrupted in consequence of the revolution, and telegrams for that country are accepted now at the sender's risk only.

Electricity for Tramcars.—The North Metropolitan Tramways Company are seeking parliamentary powers for applying electricity as a motive power on their system of tramways.

Direct Spanish Telegraph Company.—The estimated traffic receipts of this company for the month of March, amounted to £1,751, against £1,467 in the corresponding period of last year.

The Eastern Extension, Australasia, and China Telegraph Company.—The traffic receipts of this company for the month of March amounted to £37,804, and to £46,193 in the corresponding period of 1885.

Government Telephony.—From the "Statesman's Year Book" we find that in March, 1885, the Telegraph Department had 27 telephone exchanges open in various country towns, with 1,141 subscribers, paying £22,600 yearly.

The Lighting of Rouen.—A small company has been formed in Rouen for the purpose of establishing a central electric light station. The cables are to be carried overhead, and the Gerard incandescent lamp will be employed throughout the town.

Elementary Lectures.—Prof. Gray, of the University College of North Wales, intends giving a series of lectures on electricity. The lectures are specially intended for the working classes, who will only be called upon to pay a nominal fee for the course.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended 2nd April were £2,482, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Direct United States Cable Company.—The Board on April 2nd resolved upon the payment of an interim dividend of 3s. per share, being at the rate of 3 per cent. per annum, for the quarter ending March 31st, such dividend to be payable on and after the 24th inst.

Great Northern Telegraph Company. — The traffic receipts of this company amounted in March, to £20,000; from 1st January to 31st March, to £58,680; while in the corresponding months of 1885 and 1884 they amounted to £64,400 and £60,600 respectively.

The West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half month ended 31st March are £3,067, as compared with £4,010 in the corresponding period of 1885. The December receipts, estimated at £4,455, realised £4,557.

Fire at Liverpool.—Early on Wednesday morning a fire broke out in the chief telephone office at Liverpool Exchange-buildings, and all the instruments were more or less damaged. A delay of a few days will occur before telephonic communication can be completely restored in the town.

Electric Lighting Bills.—The Select Committee on these Bills is composed of the following members:—Earl Cowper, the Earl of Camperdown, Viscount Bury, Lord Balfour of Burley, Lord Rayleigh, the Earl of Crawford and Balcarres, Lord Methuen, Lord Houghton, and Lord Lingen.

Instructing the Multitude.—A lecture on the electric light was given in St. Mary's school room, Isleworth, on Monday evening last by Mr. P. J. Kelly, A.S.T.E. The experiments were numerous and successful, and the lecture was highly appreciated by the audience, especially the demonstration of the Eric Bruce system of balloon signalling.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of this company during the month of March was 3,940, estimated to produce £3,300, against 4,121 messages, producing £3,510, in the corresponding month of last year. The traffic receipts for the month of December, estimated at £2,450, realised £2,448.

Abandonment of a Central Station Scheme.—Our contemporary, the *Bulletin International De l'Electricité* remarks that the electric lighting of the Magasins du Palais Royal has been discontinued. The scheme of establishing a central electric light station in that quarter of Paris has been abandoned, as it was found impossible to obtain the necessary capital.

Killed by an Electric Gun.—Mr. C. C. Seyton, of Walton-on-Thames, was accidently killed recently while examining an electric gun at his office in George-yard, Lombard-street, City. Death was instantaneous, the charge having entered the heart. Mr. Seyton was introducing the gun, which is an American invention, into this country, and read a paper on the subject at the United Service Institution on Friday last.

Lighting Contracts.—Tenders are required for lighting by electricity the Albert Palace, Battersea. Contractors are to supply 30 arc lamps and about 3,000 incandescent lamps, five candle-power each, with all necessary steam power, dynamos, &c., for the season of about four months, commencing at the end of May next. Tenders are to be sent in by the 17th inst. to Mr. William Holland, Albert Palace, Battersea Park, S.W.

How to Catch a Thief.—Frederick Johnson, 24, was charged with stealing a pair of boots, value 4s. 11d., from the shop of Mr. S. P. Weston, of Kensington-gardens. Prosecutor displays boots outside his shop, connected by wires with an electric bell in the shop. On Tuesday afternoon the bell rang, and an assistant went to the door, and he saw the prisoner and another man making off. He pursued prisoner, and caught him in Kensington-street.

Sale of Electrical Plant. — We have received from Messrs. Wheatley Kirk, Price and Goulty, the auctioneers, a catalogue of the plant in and upon the works of the British Electric Light Company (in liquidation), which is to be sold on Tuesday next. There are nearly four hundred lots—many of which represent good and useful material — including carbons, switches, lathes, drilling and milling machines, arc lamps, dynamos, and a Marshall and Sons 14 horse-power engine.

Anglo-American Telegraph Company.—At a meeting of the Board of Directors of the Anglo-American Telegraph Company, held 2nd April, it was resolved, after placing the

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sum of £25,000 to the credit of the renewal fund, to declare an interim dividend for the quarter ending 31st March of 5s. per cent. on the ordinary stock, and 10s. per cent. on the preferred stock, less income-tax, payable on the 1st May, to the stockholders registered on the books of the company on 31st March.

PHOSPHOR BRONZE WIRE.—We understand that Mr. F. Geere Howard, of the Cleveland Works, Fitzroy-square, has been appointed sole agent for Great Britain for the phosphor bronze wire and castings manufactured by the Phosphor Bronze Company, of Brussels. It is well known that there has been considerable competition on the Continent between the makers of phosphor bronze wire, and we believe this company claims to produce a wire equal in all respects to that of any competitor.

COMPETITION FOR A PRIZE.—The King of the Belgians, Leopold II., offers annually a prize of £1,000 for the best essay on a given subject. The competition is open every alternate year to the whole world. The subject for the essay at the next international competition is "The Progress of Electricity Applied to Motive Power and Illumination: its Applications and Economical Advantages." The essays for competition, which must be written in French or translated into that language, are to be sent before January 1st, 1889, to the Minister of Agriculture, Industry and Public Works, from whom the conditions of the competition may be obtained.

THE "BUCCANEER."—The good folks at Brighton had their attention the other day attracted by the firing of fourteen rounds from a steamship which was anchored some distance off the town. Many assertions were made as to the cause of this, but on inquiry at the Coastguard Station it was ascertained that it had no special import. The vessel was the screw steamship "Buccaneer," with a crew of sixty, belonging to the Silvertown Telegraph Company, London, and had previously been signalling to the Coastguard. She was bound for London, having come from Teneriffe, where the crew have been laying telegraph wires between Spain and Teneriffe.

EXPERIMENTS IN LIGHTHOUSE ILLUMINANTS.—In the House of Commons on Tuesday Sir J. Corry asked whether the President of the Board of Trade would lay upon the table of the House an account of the expenditure incurred by the Trinity House in carrying out the experiments in lighthouse illuminants at the South Foreland, and Mr. C. Acland replied that the expenditure incurred in and about the experiments in question will amount to about £9,000. It is defrayed out of the Mercantile Marine Fund, which is a fund arising from charges on shipping. The grounds for this expense are that it will, we hope, lead, not only to increased efficiency, but to economy in the management of the lights.

HOW MUCH IS AN AMPERE?—Everybody can form some sort of mental picture as regards the flow of liquids. Thus, if we are told that a pipe discharges water at the rate of a gallon a second, we know what that means. But if we are told that the discharge taking place between two conductors across an intervening air space is so many coulombs or a certain fraction of a coulomb, we are at a loss to imagine what this really means. Most of those who last Saturday, at the Society of Arts, saw the thick bundle of sparks passing between the conductors of the Wimshurst machine would probably have been greatly astounded if told how much electricity was passing. It seemed a perfect torrent, and yet it was only the two-thousandth part of an ampere. At that rate it would take over half an hour to pass a coulomb from one electrode to the other.

THE PERFORMANCE OF SMALL ELECTRO-MOTORS.—The results of experiments by Prof. Anthony, recently published in the *Journal* of the Franklin Institute, show that there is room for improvement in small motors. We give here a few of the figures:—

Type of Motor.	Speed.	Horse-power obtained.	Commercial Efficiency.
De Meritens	3,240	0·455	49·5 per cent.
Gerard..............	3,330	0·225	39·5 „
Gerard..............	1,390	0·990	30·3 „

When comparing the energy obtainable with the weight of the motor we find that in the De Meritens motor 1 horse-power is obtained with 150lb. dead weight, whilst in the two Gerard motors it was obtained with 200lb. and 300lb. respectively. These figures compare very unfavourably with the usual English practice. Most motors, even small ones, made in this country develop 1 horse-power for about 100lb. dead weight, and there are some which weigh only about ½ cwt. per horse-power.

GORDON'S COLLEGE, ABERDEEN.—The arrangements for lighting several of the class rooms in Gordon's College with the electric light have been completed. At the preliminary trial of the dynamo and lamps, which took place last week, Dr. Beveridge, Mr. A. O. Gill, and ex-Baillie Paterson were present to see the results obtained. The dynamo has been manufactured by Messrs. D. Prentice, Menzies, and Co., Glasgow. It is driven by the college gas engine, and with 3½ horse-power showed itself at the first trial capable of giving a steady light with from 20 to 25 lamps. Five rooms have been fitted up with incandescent lamps, in all 51 lamps; but as never more than two of these rooms are required to be lighted at the same time, the current given by the machine is quite sufficient for the purpose. A great advantage in this system of lighting is that, as the lamps may be distributed throughout the whole room, the illumination is very equal, and thus extremely suitable for drawing class rooms, as was amply demonstrated at the trial. With the addition of a set of accumulators the plant now at the college is sufficient to work simultaneously from 40 to 60 lamps with a steady light.

CITY AND GUILDS OF LONDON INSTITUTE.—The sixth annual report of this Institute, dated March 31st, has just been issued, and shows satisfactory progress in its work during the past twelve months. An additional donation of £1,000 has been made by the Drapers' Company for the purchase of apparatus at the Finsbury Technical College, and the subscription from the same company has been raised from £4,500 to £6,000 for additional accommodation at the College for the Art School and for the increasing number of students in the other departments. The Mercers' Company also have increased their subscription from £2,000 a year to £3,000; the Salters' Company, from £525 to £1,000; the Ironmongers' Company, from £350 to £500; the Skinners' Company, from £500 to £1,500; the Clothworkers' Company, from £3,000 to £4,000; the Leathersellers' Company, from £500 to £750; the Carpenters' Company, from £250 to £500; and the Coopers' Company, from £105 to £157. 10s. The Cutlers' Company have promised to contribute £105 per annum; as also have several other companies who now for the first time give their adhesion and support to the objects of the Institute.

AUDENSHAW.—Mr. Abel Buckley, M.P. for Prestwich (Lancs.), has lately introduced the electric light into his new residence at Audenshaw, near Manchester. The installation consists 89 18 candle-power 65 volt lamps, supplied from 35 accumulators having a capacity of 300 ampere hours, which

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are charged during the daytime by a B_2 Victoria dynamo machine. Mr. Buckley was so convinced of the reliability of the electric light under ordinary care that he decided from the commencement not to lay on the gas to those rooms which were to be furnished with incandescent lamps. As a consequence of this step the more or less clumsy appearance of fittings doing duty for both gas and electricity has been entirely avoided, and has enabled a great deal of attention to be paid to this important matter. The fittings, supplied by Messrs. B. Verity and Sons, have been well matched with the decorations of the various rooms, and a specially designed electrolier of beaten bronze for the dining room is the work of Messrs. Ellwood and Co., of Leicester. The motive power consists of a 4 horse-power Otto gas engine, and the whole installation is under the care of Mr. Buckley's gardener. The work was carried out by the Anglo-American Brush Electric Light Corporation.

Couples in Saline Solutions.—Mr. B. C. Damien, in a paper on the E.M.F. of current yielded by metallic couples in simple saline solutions, according to an abstract in the Chemical Society's *Journal*, finds, from a large number of determinations, that the E.M.F., as a rule, decreases with the time the couple is immersed. In the case, however, of the zinc copper couple in solutions of the chlorides, the E.M.F. at first slowly increases. The E.M.F. of the current yielded by a zinc copper couple in a solution of magnesium sulphate is very constant, scarcely varying 0·017 volt during 12 months, and is not appreciably affected by changes either of the strength of the solution or of temperature. By introducing an exterior resistance of 20,000 ohms, the current becomes practically invariable, even when the couple is kept in circuit. The author proposes to employ this couple for the generation of currents of standard strength. The zinc-copper couple yields currents whose E.M.F. is almost identical for members of any class of salts containing a given acid, but varies greatly with a change of acids; amalgamation of the zinc slightly increases the E.M.F. at first, but it decreases more rapidly than is the case when unamalgamated zinc is employed. The current obtained from a platinum and amalgamated zinc couple in dilute sulphuric acid has its maximum E.M.F. when its solution contains 30 per cent. of acid.

M. Marcel Deprez's New Coulomb Meter.—In a note presented to the French Academy of Science, M. Deprez described his new coulomb meter, consisting of a U shaped glass tube, the ends of which are formed into one closed by large glass bulbs. Into one of the branches are soldered platinum wires forming electrodes, and a second pair of platinum wires are soldered into the corresponding bulb. This bulb, the whole of the branch, and a small portion of the other branch are filled with acidulated water, whilst the other bulb and the remaining portion of the branch contain air. If a current be sent through the electrodes, gas is evolved which accumulates in the bulb, depressing the level of the liquid there and raising it in the other branch. A suitable scale attached to this branch serves to indicate the total quantity of electricity which has passed in a given time. It is worthy of notice that neither the barometric condition of the atmosphere nor its hygrometric condition have any influence on the accuracy of the reading, the apparatus being hermetically sealed. The only precaution necessary to be observed is to keep the two branches of the U tube at the same temperature. The second pair of wires in the glass bulb serves to explode the mixture of hydrogen and oxygen by an electric spark, when it is desired to refill the bulb with liquid, and prepare the instrument for another reading.

An Electric Travelling Crane.—The Compagnie des Entrepots et Magasins Généraux in Paris have large warehouses in Roubaix, where the cotton bales arriving mostly from Australia and La Plata are stored before being forwarded to the different cotton mills. On account of the great fire risk no steam crane is permitted in the establishment, and the bales, which measure about 1½ cube yard, and weigh half a ton each, had, until recently, to be hoisted and generally handled by manual labour. Now the work is done by an electric travelling crane. The crane post is placed on a trolly, which runs on rails, and a rail fixed to the ceiling of the warehouse guides the upper end of the post. The jib of the crane can be raised or lowered, somewhat after the fashion of the cranes employed by builders, and thus the distance of the load from the post can be varied. The jib can also swing all round, and the bale can be deposited in any position covered by the sweep of the jib. On the trolly is fixed a small Gramme 4 horse-power dynamo, running at 900 revolutions a minute when fed with 15 amperes at 250 volts pressure. By suitable gear the dynamo, which is always kept running, can be made to hoist the load, advance the crane on the rails, swing the jib round, or raise or lower it. The current is conveyed to the crane by overhead sliding contacts. The generator is a 6 horse-power Gramme dynamo, running at 1,200 revolutions a minute, and the commercial efficiency of the whole system is said to be 60 per cent. Formerly ten men could handle 150 bales in 18 to 20 hours. The electric crane, attended by four men, does the same work in three hours.—*Revue Industrielle.*

Electro-Magnetic Action on Polarised and Natural Light.—*Wiedemann's Annalen*, No. 2, contains some interesting communications on this subject, which are commented on by our contemporary *Nature*, as follows:—"In regard to the electro magnetic rotation of light, Herr Kundt notes the fact that all simple substances hitherto examined, be they strongly magnetic or strongly diamagnetic, show positive electromagnetic rotation. Negative rotation is shown only by chemical compounds, and such as contain atoms of strongly magnetic elements (as iron salts). Positive rotation has been proved in the case of eleven elements, viz., Fe, Co, Ni, Br, Se, S, P, C (diamond), O, N, H. The question whether electromagnetic forces may not have demonstrable action on natural as well as polarised light has been lately taken up by Herr Sohncke. His guiding idea was this:—It is known that two polarised light rays from the same source, meeting at a sufficiently acute angle, interfere most if they are polarised parallel, and not at all if polarised at right angles, to each other. Now, natural rays of light from the same source behave, in regard to interference, quite like parallel polarised rays; and it seemed likely that two such rays would lose their power of interference if the direction of vibration (or greater ellipse-axis) of one of them were turned round by electro-magnetic forces 90 deg. relatively to the other, for in this case the two rays would behave like two polarised at right angles to each other. This was effected (in a way he describes). It appears that the same thing was done some years ago by Prof. Abbe, using with natural light the natural rotation of a right and left quartz instead of electro-magnetic; and this before-unpublished method is also developed by Herr Sohncke, who describes a new interference experiment with natural light.

Addresses on Telegrams.—Mr. Joseph D. Weston, M.P., having waited upon Lord Wolverton, the Postmaster-General, and presented to him a memorial from Bristol in reference to the requirement recently made for the registration of addresses,

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has just received a reply from the Postmaster-General's secretary, in which he says that, in consequence of the enormous increase which has taken place since the new rate for telegrams was introduced in the number of telegrams which have been insufficiently addressed, it has been found necessary to discontinue the practice formerly adopted of referring to directories in order to supplement these insufficient addresses. Not only was much labour involved by the references, but the telegrams of other persons which were fully addressed were thereby delayed. In the case, therefore, of vaguely-addressed telegrams their delivery is now, as a rule, effected only in the event of their falling into the hands of telegraphists or messengers who know the precise address of the persons for whom they are intended. At the same time, the Postmaster-General feels that some distinction ought to be made between cases in which the addresses of telegrams have been intentionally curtailed so as to save expense and cases in which any vagueness of the address has not been intentional, and he has accordingly given directions that when the sender has evidently done his best to give a full address a relaxation of the rule is, as far as possible, to be permitted. It is obvious, however, that differences of opinion may arise as to the latitude to be allowed, and his lordship cannot, therefore, too strongly urge that the addresses of telegrams should be made sufficiently complete to enable delivery to be effected without dispute or delay. With regard to the concluding statement in the memorial, to the effect that the action of the Department would seem to indicate a desire to compel the public to pay fees for the registration of abbreviated addresses, it is far from Lord Wolverton's wish that the registered abbreviated address system should be extended, and he would much prefer that full addresses should be given.

Electric Lighting at Greenlands, Henley-on-Thames. The final contract for lighting by electricity the above well-known residence of the Right Hon. W. H. Smith has now been definitely signed and settled, and the order placed in the hands of Messrs. R. E. Crompton and Co., thus adding another instance of the steady progress of electric lighting in private mansions, and making an addition to the large number of such contracts which Messrs. Crompton have successfully undertaken. The specification of the above work, which is of an exceptionally binding nature, has been drawn up by Mr. Musgrave Heaphy, and this gentleman, together with Mr. Massey, will act on behalf of Mr. Smith. The details of the contract may be generally stated as follows :—The plant will consist of one 12 horse-power nominal compound engine, fitted with automatic gear, fly-wheels being used, each driving by belting one shunt-wound Crompton machine of the size known as pattern No. VIII. The boiler, which, together with the engine, is being supplied by Messrs. Davey, Paxman, is also 12 horse-power nominal, the locomotive type, with special copper fire-box. The engine and boiler will be fixed on independent foundations. The rest of the plant consists of a feed water heater, an inspirator, and an electric governor, together with 60 secondary batteries, guaranteed to maintain 60 lamps at their nominal brightness for 10 hours, this point being specially insisted upon in Mr. Smith's behalf in order to avoid Sunday working. The mains, which are heavy enough to carry current for 300 lamps (110 volts), are laid underground from the engine room to the house, and are of extra heavy insulation. The total number of lamps at present required is 200, but everything is arranged so that, if desired, an addition can be made to the lamps hereafter. The fittings are generally speaking of a simple character, where-ever suitable flexible pendants being used, in other cases brackets or table standards are employed ; all switches and cut-outs have to be mounted on non-combustible bases, and, we need hardly add, all wires have to be run in strict accordance with the rules of the Phœnix Fire Office. The contractors have to guarantee the efficient working of the installation in every respect for a period of twelve months, including the secondary batteries. The contract is to be completed by July 1st, after which date we shall hope to be able to supply some further details as to the actual working and the actual arrangement of the plant.

The U.S. Government and the Bell Telephone.—On the 23rd ult. a bill of complaint was brought by the United States Government, in the States Circuit Court at Columbus, to annul and vacate the Bell telephone patents, on the ground of fraud, alleged to have been practised by Alexander Graham Bell in obtaining his patents by the connivance of persons holding official positions in the U.S. Patent Office, and by misrepresentations made in his behalf. With Mr. Bell's name are coupled as respondents several large telephone companies in the States, who are summoned to appear by May 1 and to file answers to the charge by June 1. It is complained that Bell's patent of February 14, 1876, was so ambiguously worded as to cover antecedent and future inventions and to deceive the examiners ; that it was designed as an improvement in telegraphy and not as a means of transmitting speech, which Bell knew to have been already invented by the German, Philip Reis. It is also alleged that Elisha Gray, of Chicago, filed a similar application on the same day, but before Bell filed his ; and that the particulars of Gray's caveat, which really described a speaking telephone, was wrongfully divulged to Bell by the examining officer of the Patent Office. Bell, it is stated, followed up this knowledge, and induced some of the patent officers to further violate the statutory requirements of secrecy by setting on foot an inquiry for Bell's benefit as to the precise time of day when Gray's caveat was filed, "and thereupon, without any certain proof, and contrary to law and the custom of the office, it was determined, contrary to the fact that said caveat (Gray's) was filed after said application (Bell's), although on the same day." The complaint then sets forth that Bell now having access to Gray's invention, recast his own specification and claims, so as to exclude those of Gray, especially by the substitution of the terms "undulatory" currents for "pulsatory," and "gradually" for "alternately." Further, that by false representation of Gray's attorney, Bell induced him to persuade Gray that it was no use proceeding with his patent, and that Gray in consequence did not proceed with it as he might legally and rightfully have done. Bell it is asserted did not obtain articulate speech on his telephone till March 10th, 1876, three days after the patent was issued to him, and this not with any device described in his specification, but by the method described in Gray's caveat, to which he, Bell, had had access. Even, however, if Gray's caveat had not been filed, Bell's patent, it is contended by the State prosecution, would still be void, because "all his claims are bad in form and substance." They are also invalidated by the prior inventions of Reis, Varley, Meucci, Gray, Edison, Eaton, and others. Lastly, it is charged in respect of the magneto telephone patent of January, 1877, that the invention was Dolbear's, but was appropriated by Bell, who, by misrepresentation, deterred the inventor from taking steps to protect it by a patent. This extraordinary case is exciting much attention in the States, where enormous interests are involved in the issues to be tried.

The Resistance in the Voltaic Arc.—According to Edlund, the apparent resistance of the voltaic arc consists, as

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it were, of two parts, one independent of the length of the arc, and the other proportional to it. Call the resistance w, the length of arc l, while a and b are two constants, then $w = a + b\,l$. This holds if current is constant while length of arc is changed. Of the constants b is less when the current increases, while a is almost independent of the strength of the current, and of the electromotive force of the source of electricity; it is only when this is so much diminished that an arc light is scarcely formed that the value of a becomes less. The question may be put whether this constant a represents a resistance of transition, which takes place at the surface of contact of the electrodes and the air, or whether it has its origin in an electromotive force, for the diminution in the strength of the current expressed by a might be explained by either of these assumptions. From previous researches he finds a represents an electromotive force in opposition to the principal current. Frölich came to the conclusion that either of the assumptions are reconcilable with these observations, though he seems inclined to think that the constant a represents an electromotive force, as well as a resistance of transition. Frölich probably considers that a cannot be exclusively an electromotive force, for in this case it would have what, in his opinion, is the absurdly high value of 39 volts. Peukert has made a series of observations on this subject, in which the strength of the current varied from 10 to 30 amperes. He found that the apparent resistance of the luminous arc may be represented by the formula $w = a + b\,l$. If it be assumed that the constant a is an electromotive force, its value according to Peukert must amount to 35 volts; a value which appeared to him so high that he did not venture to assume it could have its origin in an electromotive force, but that, partly at least, it represents a resistance of transition. From Edlund's previous investigations it follows that a is independent both of the magnitude of the source of the current and of its strength, provided this does not sink to the lowest limit in which a voltaic arc may be formed. In his first experiments on this subject he calculated a as an electromotive force, expressed in Bunsen elements. Seven successive experiments made with a current of 53 to 79 Bunsen elements gave the following results :—$a = 24{,}416$; 25,962; 25,354; 20,951; 21,637; 21,483; 23,119; the mean of which is $= 23{\cdot}315$. This holds when the light is produced between carbon points of the ordinary kind. If it be assumed that 1 Bunsen element is equal to 1·7 Daniell's, and that this is 1·08 volt, 1 Bunsen = 1·8 volt. If this number be multiplied by the mean in question, we obtain 41·97 volts. The mean of this number and of that found by Frölich and Peukert (39 and 35) gives 38·66 volts. The view that the constant a partly represents a resistance of transition is disproved by the investigations of Victor von Lang, who succeeded in proving that the voltaic arc does contain a counter electromotive force which is equal to 39 volts. As this value of the counter force in the arc is almost equal to the value of the constant a above given, it follows that there is no resistance of transition in the voltaic arc, and that therefore the entire diminution of the strength of the current which results from the production of the arc light is caused by the resistance of the arc $b\,l$, and by the electromotive force contained in it.

Central Electrical Laboratory in Paris.—The International Society of Electricians in Paris have recently presented to the French Minister of Posts and Telegraphs a report on the proposed central electrical laboratory. At the Electrical Exhibition in Paris in 1881 it had been decided to devote any surplus which might be made to the erection of a laboratory or some such institution. We learn from the *Revue Internationale de l'Electricité*, the paper of the society, that the sum actually at their disposal was at the close of the Exhibition about £13,000. M. George Berger, the president of the society, has since contributed £240, making a total of £13,240. The committee appointed by the society to elaborate a scheme direct attention to the fact that at the present moment there does not exist in Europe any large and independent electrical laboratory. Institutions of that nature, but on a very limited scale, are generally found annexed to some university or polytechnic school, and the only attempt to establish a laboratory on a wider basis was in connection with the exhibition in 1882 in Munich. Even this is annexed to the polytechnic school in Munich, and has, for want of funds, never developed in the manner anticipated by its founders. A central laboratory, to be of real use to the progress of electrical industries, must be accessible, without distinction of nationality, to all scientists, inventors, and manufacturers, and it must, moreover, be free from any supervision or restriction imposed by the State or any of the national scientific societies in France. The primary object is to give the public an unbiassed opinion on any invention, French or foreign, which is submitted for test. It is also intended to be a central office for electrical standards and exact measurements. A free library and reading room are to be attached, and lectures on electrical subjects are to be given. The administration is to be in the hands of a committee composed of the different electrical societies in Europe, and the management is to be entrusted to a scientific electrician of high standing, assisted by a staff of engineers. It is suggested that the municipality of Paris make a present of the site for the laboratory, which will be a building covering about 1,100 square yards, having two stories and a basement. The cost of this building is estimated at £14,000, to which must be added the cost of machinery, apparatus, and internal fittings, valued at £5,000—total, £19,000. This exceeds the funds in hand by about £6,000, which will have to be asked from Parliament. An annual subvention of £1,200 will also have to be asked from Government. The annual working expenses are estimated as follows :—

Salaries	£1,000
Purchase and maintenance of apparatus	1,000
Maintenance of building and furniture	200
Experiments	600
Contingencies	400
	£3,200

We cannot help thinking that the committee of the International Society of Electricians have greatly underestimated the annual working expenses. It is difficult to see, for example, how the services of a scientific electrician of high standing, assisted by a staff of experienced engineers, can be secured at a total salary of £1,000. The appointment of a scientific manager is of so much importance that the salary of £1,000 would hardly be sufficient to cover this alone, to say nothing of the salaries of the engineers and the wages of the attendants. It must not be forgotten that a favourable verdict obtained for any new invention from the central laboratory will be of immense commercial value, and that therefore the men whose duty it will be to pronounce a verdict must be paid on a sufficiently liberal scale to put them beyond the reach of a bribe. The sum of £600 set down to defray the cost of experiments is also ridiculously small. To make careful experiments the apparatus must in each case be more or less altered and adapted, and when the experiments are to embrace all the applications of electricity, from a surgical incandescent lamp and primary cell to a thousand-light dynamo, the amount of appliances required will represent a considerable annual outlay.

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REPORT ON ECONOMY TEST OF A CROMPTON DYNAMO, DRIVEN DIRECT BY A WILLANS HIGH-SPEED ENGINE.

The object of the trial was :—

1st. To ascertain correctly the cousumption of water per indicated horse-power per hour, of the new type of tandem compound high-speed engines recently introduced by Willans and Robinson, of Thames Ditton.

2nd. To ascertain what percentage of the indicated horse-power in the engine cylinders can be obtained as useful electrical horse-power at the terminals of the Crompton dynamo, driven direct by one of these engines.

3rd. The above data being correctly ascertained, to show the consumption in pounds of water, hence pounds of coal per useful electrical horse-power per hour.

Mr. J. Macfarlane Gray, Chief Examiner of Engineers to the Board of Trade, Mr. W. H. Massey, C.E., of Twyford, Berks, Dr. Fleming, of University College, London, were invited to conduct the trials. On the date on which they were to take place, Mr. Massey, being unavoidably absent owing to illness, requested Mr. E. H. Liveing to take his place. Mr. Macfarlane Gray and Mr. Liveing took charge of the indicating apparatus, measurements of water used, and all measurements relating to the engine. Dr. Fleming took all the electrical measurements, and afterwards verified the instruments used.

wrought iron magnets 24in. by 7in. thick, the armature being 36in. long and 16½in, in diameter. One end of the armature spindle is bolted to the crank-shaft of the engine by a solid steel coupling ; the other or commutator end of the spindle is carried in a spherical bearing, so formed as to be easily adjusted and kept in line with the three main bearings of the engine crank shaft. This dynamo was designed to give an electrical output of 600 volts and 120 amperes at a speed of 400 revolutions. This is equal to 72,000 watts or about 97 electrical horse-power.

Means Adopted to Ascertain the Quantity of Water used by the Engine.—The engine was supplied by a pair of nominal 20 horse-power locomotive boilers made by Messrs. Marshall, Sons, and Co., of Gainsborough, being two of the boilers usually employed for driving Messrs. Crompton's works. The ordinary feed arrangement was disconnected, and the boilers were supplied by a pair of Hancock's inspirators drawing from an iron tank, which at the commencement of the trial was filled up to a gauge mark, and at the end of the trial was again filled up to the same mark. The whole of the water passed into this tank through a barrel mounted on an accurately adjusted scale beam, so that its actual weight was taken and no calculations were necessary. The coal used during the trial was weighed, but as the boilers were not specially cleaned for the occasion the evaporative efficiency was not high. However, the actual results obtained are noted in the tables.

CURVES OF ELECTRICAL OUTPUT AND MECHANICAL INDICATED HORSE-POWER OF VIENNA DYNAMO No. 1,123 AND EXCITER.

No. 1 = Electrical H.-P. of $\frac{72}{600}$. No. 2 = Indicated H.-P. of Large Willans Engine.

No. 3 = Electrical H.-P. of $\frac{72}{600}$ – Exciter Electrical H.-P.

Description of the Engine.—The engine tested is one of Messrs. Willans and Robinson's latest design and make. It is non-condensing and single acting, having two high-pressure and two low-pressure cylinders, the high-pressure cylinders being 11in. diameter, placed on the top of the low-pressure cylinders, which are 18in. in diameter, both having 9in. stroke. The arrangement of this engine was fully described and shown with diagrams during the discussion on Mr. Imray's paper on high-speed engines recently read before the Institution of Civil Engineers. The engine was designed to run at a speed varying from 200 to 400 revolutions, and to develop at the higher speed 140 indicated horse-power, with boiler pressure of 140lb. per square inch. As a matter of fact it will be seen from the indicator diagrams that the engine is rather too large for this work.

The Indicating gear consisted of four Crosby indicators; the high pressure indicators had 120lb. springs, the low-pressure ones 50lb. springs. The two low-pressure indicators were also arranged to indicate the variations of the receiver pressure, for, as the under side of the high-pressure cylinder is open to the receiver, the variations of pressure in the latter affect the power of the engine.

The number of revolutions was taken from a Youngs speed indicator, driven directly off the engine, checked in addition by counting the revolutions with an ordin ary geared speed counter (at the end of the spindle) at the time that each set of indicator diagrams was taken.

The Crompton dynamo is of the vertical type, having

Method Adopted to Ascertain the Electrical Output.—A large rheostat or resistance coil was prepared, consisting of a continuous band of wire gauze stretched tightly over a large frame, and so arranged with switches that any desired portion could be short-circuited and the resistance thus varied. The conductors from the terminals were led to this rheostat, and from thence to the measuring instruments, which were placed in Messrs. Crompton's test room. These instruments consisted of two of Messrs. Crompton's current indicators, specially constructed for the occasion, and carefully calibrated by Dr. Fleming by means of a Clark standard cell, verified against those used by Lord Rayleigh, in conjunction with a low resistance, also carefully determined. The current indicators were calibrated by passing the same current through them and the low resistance coil, and measuring the difference of potential at the ends of the latter by means of the said cell.

Separate Exciting.—The dynamo had its field magnets excited by a separate machine. During the trials this separate machine was driven by its own Willans engine, the steam for which was supplied from a separate boiler. The electrical horse-power used in exciting was subtracted from the electrical output, as will be hereafter shown.

Electrical Measurements of Dynamo:—

Resistance armature, hot = 0·255 ohms.
Resistance magnet coils, hot = 0·33 ohm.
Loss in armature at 120 amperes = 30·6 volts.
Loss in magnet coils at 64 amperes exciting current = 21·1 volts.

Watts expended in armature	=30·6 × 120=	3,670
Watts expended in exciting	=21·1 × 64=	1,350
Watts in external circuits, *i.e.*, useful output	= 600 × 120=	72,000
Total watts ...		=77,020

Percentage of total electrical power in external circuit =93·5 per cent.

It was arranged that the indicated horse-power should be worked out from the indicator diagrams by Mr. Macfarlane Gray and Mr. Liveing independently.

Tables I. to III. give the results worked out from 48 diagrams by the former, who employed a planimeter.

TABLE I.

Time.	Planimeter.	Difference.	M. Pressure.	Rev. ÷ 2.	I.H.P.
A.L.	1302				
5:40	1321	19	7·6	172	9 28
	1361	40	16·		58 65
5:45	1380	19	7·6	189	10 2
	1420	40	16·		64·29
6:00	1439	19	7·6	174	9·40
	1485	46	18 4		68·25
6:05	1504	19	7·6	176	9·51
	1553	49	19·6		73·44
6:20	1571	18	7·2	175	8 95
	1620	49	19·6		72·96
6:25	1639	19	7·6	176	9·51
	1681	42	16·8		63·00
6:40	1702	21	8·4	170	10·15
	1746	44	17·6		63·75
6:45	1765	19	7·6	163	8·80
	1813	48	19·2		66·60
7:00	1833	20	8·0	176	10 00
	1880	47	18·8		70 50
7:05	1900	20	8·0	165	9 38
	1948	48	19 2		67·35
7:20	1965	17	6·8	175	8·44
	2013	48	19 2		71·40
7:25	2033	20	8·0	179	10·16
	2081	48	19 2		73·20

TABLE II.

Time.	Planimeter.	Difference.	M. Pressure.	Rev. ÷ 2.	I.H.P.
B.L.	2081				
5:30	2102	21	8·4	165	9 84
	2151	49	19·6		68 9
5:35	2169	18	7·2	157	8·03
	2218	49	19·6		65·5
5:50	2235	17	6·8	180	8·68
	2281	46	18·4		70·6
6:10	2300	19	7·6	168	9·01
	2349	49	19 6		70·5
6:15	2369	20	8·0	182	10·34
	2416	47	18 8		72 8
6:30	2435	19	7 6	177	9·56
	2484	49	19·6		73·9
6:35	2504	20	8·0	177	10·05
	2 58	54	21·6		81·3
6:50	2579	21	8·4	168	10·65
	2625	46	18·4		65·8
7:10	2646	21	8·4	162	9·68
	2691	46	18·0		62·0
7:15	2709	18	7·2	155	7·92
	2758	49	19·6		64·7
7:30	2778	20	8·0	174	9·89
	2828	50	20·0		74·1

Table IV. gives the results worked out from 24 diagrams only, by the latter, who used scales. The slight difference in the measurement produces a divergence in the final result as follows:—Mr. Macfarlane Gray shows the mean indicated horse-power during the experiment to be 113·98, and the water evaporated per indicated horse-power per hour 22·95lbs. Mr. Liveing shows a mean indicated horse-power during the experiment of 110·76, and the water evaporated per indicated horse-power per hour 23·66lbs. This difference is not due to the selection by Mr. Liveing of 24 in place of the whole 48 diagrams, for the same 24 diagrams taken at Mr. Gray's measurement give a mean of 113·26 horse-power, against 113·9 horse-power for the whole 48.

TABLE III.

Time.	Planimeter.	Diff. = M Pressure.	Rev. ÷ 2.	I.H.P.
B. H.	2120			
5:30	2151	31	165	36·3
5:35	2181	30	157	33·5
5:45	2206	35	189	33·6
5:50	2237	31	180	39·6
5:55	2269	32	180	40·8
6:15	2300	31	182	40·0
6:20	2325	25	175	31·1
6:30	2356	31	177	38·9
6:35	2388	32	177	40·2
6:50	2421	33	168	39·4
6:55	2450	29	155	31·9
7:10	2482	32	162	36·8
7:15	2512	30	155	33·0
7:30	2545	33	174	40·8
A. H.				
5:40	2573	28	172	34·2
6:00	2600	27	174	33·4
6:05	2628	28	176	35·0
6:10	2656	28	168	33·4
6:25	2683	27	176	33·7
6:40	2713	30	160	34·1
6:45	2742	29	163	33·6
7:00	2771	29	173	36·2
7:05	2808	29	165	34·0
7:20	2827	27	175	33·6
7:25	2854	27	179	34·3

TABLE IV.

Willans' Engine Tests. Chelmsford, 12th December, 1885.

Diagram.	Time.	Revolutions in ½ min.	Mean Pressure of Low Pressure Cylinder.	H.P. of do. × by 2.	Mean Pressure of Receiver.	H.P. of do. × by 2.	Mr. Gray by Planimeter. Mean Pr. of Low Pres. Cylinder.	H.P. of do. × by 2.	Mr. Gray by Planimeter. Mean Pressure of Receiver.	H.P. of do. × by 2
	p.m.		lbs. sq. in.		lbs. sq. in.		lbs. sq. in.		lbs. sq. in.	
A. L. 1......	5:45	189	16·35	65·65	7·34	9·85	16·0	64·29	7·6	10·2
2......	6:5	176	18·38	68·73	7·41	9·26	19·6	73·44	7·6	9·51
3......	6:25	176	16·81	62 85	7·59	9·48	16·8	63·00	7·6	9·51
4......	6:45	163	18·48	63·99	7·65	8·85	19·2	66·60	7·6	8·80
5......	7:5	165	18·60	65·20	7·63	8·93	19·2	67·35	8·0	9·38
6......	7:25	179	18·40	70·17	7·38	9·38	19·2	73·20	8·0	10·16
Mean	..	..	..	66·1	..	9·29	..	67·98	..	0·59
B. L. 1......	5:35	157	19·30	64·33	7·70	8·58	19·6	65·50	7·2	8·03
2......	5:50	180	17·55	67·12	7·46	9·53	18·4	70·60	6·8	8·68
3......	6:10	168	19·27	68·80	7·55	9·00	19·6	70·50	7·6	9·01
4......	6:35	177	21·05	79·15	7·95	9 99	21·6	81·3	8·0	10·05
5......	6:50	168	19·50	69·60	8 58	10·23	18·4	65·8	8·4	10·05
6......	7:15	155	18·75	61·75	7·22	7·94	19·6	64·7	7·2	7·92
Mean	..	..	..	68·4	..	9·21	..	69·7	..	8 95
			High Press. Cylndr	Press. of do. × by 2.			High P. Cylindr. Mr Gray	H.P. of do. × by 2.		
			lbs. s. i.				lbs. sq. i.			
A. H. 1......	5:40	172	27·10	33·09	..	..	28	34·20	..	..
2......	6:0	174	26 35	32·55	..	..	27	33·40	..	..
3......	6:20	175	26·25	32·61	..	..	25	31·10	..	..
4......	6:40	170	29·00	35·00	..	..	30	34·10	..	..
5......	7:0	176	27·60	34·48	..	..	29	36·20	..	..
6......	7:20	175	25·60	31·80	..	..	27	33·69	..	..
Mean	..	..	..	33·25	..	..	..	33·7	..	..
B. H. 1......	5:30	165	30·30	35·49	..	..	31	36·30	..	..
2......	5:50	180	29·70	37·95	..	..	31	39·60	..	..
3......	6:15	182	28·60	36·95	..	..	31	40·00	..	..
4......	6:30	177	29·45	37·00	..	..	31	38·90	..	..
5......	6:55	155	28 85	31·74	..	..	29	31·90	..	..
6......	7:15	155	29·52	32·49	..	..	30	33·00	..	..
Mean	..	..	..	35·27	..	..	..	36·60	..	..

Table V. gives Dr. Fleming's measurements of electrical horse-power, each of these measurements being taken simultaneously by signal with the corresponding set of indicator diagrams.

Table VI. is compiled from the former tables for the purpose of showing what percentage of the indicated horse-power in the engine cylinders is obtained as useful electrical

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indicated horse-power at the terminals of the dynamo, and diagram No. VII. shows the same graphically. For the purpose of compiling Table VI. and diagram VII. the mean of Mr. Macfarlane Gray's and Mr. Liveing's figures has been taken.

TABLE V.

Dynamo Economy Trials.

Time.	Corrected Current.	E.M.F. Corrected to Brushes.	Watts.	E.H.P.
5:30	124·3	530	65879	88·31
5:35	119·1	492	58597	78·53
5:40	120·0	487	58440	78·34
5:45	124·3	522	64884	86·97
5:50	120·0	501	60120	80·59
5:55	129·5	551	71354	95·65
6:0	123·1	513	63150	84·65
6:5	125·3	522	65406	87·68
6:10	124·3	492	61155	85·02
6:15	129·5	524	67858	90·06
6:20	127·4	508	64719	86·75
6:25	123·1	475	58472	78·38
6:30	130·5	528	68904	92·36
6:35	129·5	513	66433	89·05
6:40	124·3	496	61652	82·64
6:45	124·3	481	59788	80·14
6:50	126·3	497	62771	84·14
6:55	121·2	465	56358	75·57
7:0	131·5	522	68643	92·01
7:5	128·4	496	63686	85·37
7:10	123·1	461	56749	76·07
7:15	122·2	455	55601	74·53
7:20	129·5	511	66174	88·70
7:25	129·5	508	65786	88·18
7:30	129·5	512	66304	88·89
Total	...	...	...	2118·58
Mean	...	...	...	84·74

TABLE VI.

Combined Economy Trials.

Time.	Mean Indicated H.P.	Electrical H.P.	Extg. Electrical H.P.	Elec. H.P. corrected.	Commercial Efficiency.
5:30	111·74	88·31	1·9	86·41	77·3
5:35	107·74	78·53	1·79	76·74	71·2
5:40	101·57	78·34	1·63	76·71	75·7
5:45	106·76	86·97	1·28	85·69	79·8
5:50	...	80·59	1·28	79·31	...
5:55	118·05	95·65	1·9	93·75	79·2
6:0	110·62	84·65	1·9	82·75	74·9
6:5	115·47	87·68	1·69	85·99	74·5
6:10	...	85·02	1·53	83·49	...
6:15	117·50	90·06	1·95	88·11	75·1
6:20	113·76	86·75	1·79	84·96	74·8
6:25	106·3	78·38	1·33	77·05	72·8
6:30	123·26	92·36	2·02	90·34	76·0
6:35	130·47	89·05	2·26	86·79	66·5
6:40	108·45	82·64	1·85	80·79	74·2
6:45	108·0	80·14	2·15	77·99	73·0
6:50	117·24	84·14	2·21	81·93	70·0
6:55	...	75·57	1·9	73·67	...
7:0	115·84	92·01	2·1	89·91	78·0
7:5	109·48	85·37	2·26	83·11	76·6
7:10	108·48	76·07	1·9	74·17	68·2
7:15	103·9	74·53	1·9	72·63	70·0
7:20	112·54	88·70	1·85	86·85	77·1
7:25	115·7	88·18	1·63	86·55	75·0
7:30	124·79	88·89	1·79	87·10	69·8
Total......	2477·67	2118·58	45·71	2072·79	1629·1
Mean......	112·62	84·74	1·83	82·91	74·05

The electrical horse-power absorbed in exciting is deducted from the electrical horse-power shown on Table V., as would have been the case if the dynamo had been self-exciting, and the nett electrical horse-power is shown in column 5 of Table VI. The efficiency in this table varies from 79 to 66 per cent., the mean throughout the trial showing 74·05 per cent. of the indicated horse-power given off as nett useful electrical horse-power at the terminals of the dynamo.

It was originally intended to make the trial of four hours' duration, but it was found difficult at first to make the times of the indicator diagrams coincide exactly with those of the electrical readings. The early ones were therefore rejected, and those of the last two hours only taken. It will be seen from the diagram, Table VII., that there was a considerable variation in the horse-power, the cause being that both the large engine and the exciting engine were incomplete, being intended for use with electric governors, which were not ready in time for the trials; moreover, the load being a heavy one for the boilers, the steam pressure at first was not kept very regularly.

Owing to the system adopted of weighing the water, it was possible to obtain with the utmost exactness the quantity used during the two hours of the trial; but this could not be the case with the coal, as the quantity was weighed out for the whole run. However, dividing the total weight of water evaporated during the four hours by the coal consumed during the same period we find that 7·42lb. of water only were evaporated per lb. of coal. The total weight of water evaporated during the actual trial, lasting two hours two minutes, was 5,320lbs.; therefore, the results in lbs. of water per horse-power and per electrical horse-power per hour, viz., 23·2lb. and 31·31lb. respectively, are exceedingly good—in fact, there are no published results which show even an approximate approach to this measure of steam consumption per electrical horse-power.

Good though these results are, it would hardly be fair either to the engine or dynamo to take them as representing their maximum efficiency, for the boilers were not sufficiently powerful for the work and could not be cleaned for the trials. It is therefore more correct to eliminate the boilers from the calculation by taking the steam used instead of the coal, though even then an error creeps in, as the steam was probably rather wet from insensible priming due to the forcing of the boilers. Moreover, the condensation in the steam pipes was considerable, owing to the temporary nature of the connections. When these drawbacks are taken into account, and it is further considered that it was apparent from the indicator diagrams taken during the trial that far greater economical results would have been obtained at a higher horse-power had the boilers permitted it, there seem fair grounds for expecting a consumption little exceeding 20lb. of steam per indicated horse-power per hour, or 27lb. per electrical horse-power per hour, and this, with a good boiler, is equal to 2lb. and 2·7lb. coal respectively. Boiler pressure 130lb. to 140lb.

In cases where a condenser can be used there would be a further increase in the ecomony.

These trials show that the view held for so many years that a high-speed engine must necessarily be wasteful must be definitely given up, for in this case we have a high-speed engine showing under not the most favourable circumstances an economical use of steam which need not fear comparison with that of any other slow-speed steam engine; but it is capable, as has been shown, of still further improvements.

The bearing of this fact upon the future of electric lighting is most important. A great step has been made in the direction of economical production of electrical energy from the fuel, and it seems probable that the typical dynamo of the future for large installations must be one driven direct by a high-speed steam engine of from 150 to 200 horse-power.

(Signed) J. MACFARLANE GRAY.
J. A. FLEMING.
E. H. LIVEING.

MINIMUM WASTE AND MAXIMUM ECONOMY.

BY PROFS. W. E. AYRTON, F.R.S., AND JOHN PERRY, F.R.S.

We are all of us much indebted to Sir William Thomson for his remarkable paper given at the meeting of the British Association in 1881, since it possessed a double value. First, it directed the attention of electrical engineers to the importance of determining the conditions of maximum economy, when we had a choice of expenditure in two directions of such a nature that increasing the one expenditure diminished the other; for example, it was this paper of Sir William Thomson's that suggested to us the method that we published

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about a year ago for determining what was the most economical potential difference to use with a particular type of incandescent lamps.* Secondly, this paper of Sir W. Thomson's showed people how to determine the most economical gauge to give to a wire when we knew the current, the yearly value of a horse-power, the value of copper, and the rate of interest on money. But what we have desired to point out in our paper "On Economy in Electrical Conductors," recently published in *The Electrician*, is that, although his rule is perfectly correct mathematically, it cannot generally be used to determine the conditions of maximum economy, because some electrical condition, either in addition to the strength of the current, or in place of the strength of the current, is given us. Indeed, in the application made by Sir William Thomson of his own rule in his inaugural address he *starts* by assuming that we know the potential difference at the dynamo end of the line, which he takes as 80,000 volts. He next says let us employ a solid copper wire half an inch in diameter, &c.

To obtain the most economical current he uses his rule

$$C = \frac{t}{r},$$

and as 48·85 is the value he takes for t, and 0·2035 ohm the value he takes for r, the resistance per mile of his conductor half an inch in diameter, he concludes that the proper value to give to C is 240 amperes.

But we deferentially suggest that this is incorrect, because, as we pointed out, his rule has been obtained by finding the value of r that makes the total waste per mile

$$C^2 r + \frac{t^2}{r}$$

a minimum when C is constant and r a variable, and it cannot, therefore, be used to find the value of C when r is fixed and C is the variaable, which are the conditions of Sir William's Niagara problem, as he has stated it. In fact, if we regard r as constant, and C as the variable, the value of C that makes the expression for the total waste per mile a minimum is C equal to nought, and it is perfectly true that C equal to nought leads in this case *to minimum waste, but not, of course, to maximum economy*. In fact, when C alone is the variable a consideration of the waste does not lead to a practicable answer; and consequently with the conditions that Sir William Thomson has taken with the Niagara problem a method of procedure different from the one that he has adopted must be followed in order to determine the value of C that should be used to obtain maximum economy.

In the problem solved in our paper we have considered that the power given out at the other end of the line was fixed, but as this is not one of the conditions of the Niagara problem the method followed in that paper cannot be employed either.

Probably the simplest way of attacking the Niagara problem is to determine the value of C that makes the *efficiency a maximum*. This may be done as follows :—

If V is the potential difference at the dynamo, n the length of the line in miles, then the power in watts received at the far end is

$$C\,(V - C\,n\,r),$$

and the power put into the line in watts equals

$$C\,V + n\frac{t^2}{r},$$

the second term in the latter expression representing the power put in in the form of interest on the capital that has been expended on the conductor. Hence the efficiency equals

$$\frac{C\,(V - C\,n\,r)}{C\,V + n\frac{t^2}{r}}.$$

Differentiating with respect to C, and equating to nought, we find that

$$C = \frac{t}{r} \times \frac{\sqrt{n^2 t^2 + V^2} - n\,t}{V}$$

makes the efficiency a maximum.

* *Electrician*, page 309, February 21st, 1885.

Hence we see that $\frac{t}{r}$, as given by Sir William Thomson, must be multiplied by the factor

$$\frac{\sqrt{n^2 t^2 + V^2} - n\,t}{V},$$

a factor depending on the length of the line, and on the potential difference at the dynamo, in order to obtain the proper value of C.

For V equal to 80,000 volts and n equal to 300 miles this factor becomes 0·8333,

so that with the 300 miles of copper conductor half an inch in diameter the proper current to employ with the particular number of hours of working, the cost of copper, the rate of interest on money, and the yearly value of a horse-power at Niagara taken by Sir W. Thomson is, we submit, not 240 amperes, as given in his inaugural address, but

$$240 \times 0{\cdot}8333,$$

or 200 amperes,

in order to obtain maximum efficiency.

LITERATURE.

International Telegraph Convention; with Berlin Revision of Service Regulations and Tariffs. Translated by ALFRED BRASHER, Director of Traffic, Indo-European Government Telegraph Department.

Mr. Brasher has again translated the "International Telegraph Convention," which becomes more voluminous after each succeeding Convention, and now contains 111 pages. The following article (No. LXII.) relating to semaphoric telegraphs should be made known to captains of ships :—

1. Semaphoric telegrams are telegrams exchanged with ships at sea by the medium of semaphores established, or to be established, on the coasts of any of the contracting States.

2. They should be written either in the language of the country in which is situated the semaphore station which has to signal them, or in signals of the universal commercial code. In the latter case they are considered as cipher telegrams.

3. When they are for ships at sea the address should contain, in addition to the ordinary direction, the name or official number of the vessel and its nationality.

4. In the case of Government semaphoric telegrams signalled from a ship at sea, the seal is replaced by the distinctive sign of command. The name of the vessel should be given.

5. Every semaphoric telegram must contain the official instruction semaphoric in the preamble.

6. The charge for telegrams exchanged with ships at sea, by the medium of semaphores, is fixed at one shilling and eightpence per telegram. This charge is added to the cost of its transmission by the electric telegraph, calculated according to the ordinary rules. The total is collected from the sender for telegrams addressed to ships at sea, and from the receiver for telegrams signalled from ships at sea. In the latter case the instruction, — s. — d. *to be collected*, should be inserted in the preamble. If it cannot be collected, the terminal administration is paid the amount of charges due, by means of a reimbursement draft. Article LXIII. says :—

(1.) Telegrams from a ship at sea are transmitted to their destination in signals of the commercial code when the ship requests it.

(2.) When the ship does not request it, they are translated into ordinary language by the chief of the semaphore station, and transmitted to destination.

(3.) Telegrams which it has been impossible to signal from semaphore stations to the ships to which they are addressed within thirty days of the date of their original deposit (date of deposit included) are considered as dead letters.

(4.) In case the ship to which a semaphoric telegram is addressed does not arrive within the term of twenty-eight days, the semaphore station forwards a service notice to the sender on the morning of the twenty-ninth day. The sender has the power, on paying for an ordinary aërial telegram of ten words, to request the retention of his telegram for another thirty days, and so on. If this request is not made, the telegram is treated as a dead letter on the thirtieth day.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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THREE ELECTRIC LIGHTING ACT AMENDMENT BILLS.

There is at length some prospect of the Electric Light being emancipated from the shackles put upon it four years ago. The Act of 1882 was a failure from the very first, unless we are to suppose that its framers intended it as a bar to the progress of the new illuminant, in which case they have achieved only a short-lived success. In other directions than those embraced by the Act the Electric Light has grown, both in efficiency and popularity, to such an extent that its title to be ranked as a legitimate claimant for the lighting of towns and private houses can no longer be denied. The authors of that singular piece of socialistic legislation which proposed to extinguish every solvent Electric Lighting industry "for the price of old iron" now confess that prospective confiscation is not a very promising subject to legislate upon, however alluring may be the field of immediate confiscation where nobody's leave has been asked beforehand. The present Government, which was also the Government of 1882, have been brought to their knees by the reception given to Lord RAYLEIGH'S and Viscount BURY'S Amendment Bills in the House of Lords, both of which virtually repeal the existing prohibitory Act, and one of which is pretty sure to become law. In these circumstances a rival Amendment Bill is now proffered by Ministers, embodying the concessions they are prepared to make in the direction of Free Trade for Electric Lighting industry

In discussing the character of this peace-offering, we cannot lose sight of the early history of Mr. CHAMBERLAIN'S Act. The then President of the Board of Trade originally proposed that the period during which electric lighting undertakers should be free to carry on their business without liability to being summarily bought up by a local authority for a nominal sum was seven years. This term, it is true, was extended under pressure in the House of Commons to fourteen years; and afterwards, thanks to the House of Lords, a further grace of seven years was grudgingly assented to. But it was confessedly a mere try-on; and, as nobody responded to this spider-like invitation, although it has been open for nearly four years, the present Board of Trade have consented to further enlarge the term by ten years, or by ten years more if the Board of Trade and Parliament see fit, or by twelve years if the local authorities do not care to buy at the expiration of the first thirty. The conditions of purchase, however, remain as before; the spider is the same, though the net is bigger. All the difference we can see between the first overture and the last is that the agony phase is postponed. By the time the final decade has been reached all the strong and wideawake flies will have made off with the spoils, leaving the weakly ones to die of fright, or be devoured in the parish parlour. If honest people will not invest capital in a concern that is doomed to extinction at the end of seven or fourteen years, the only effect of extending the period will be to induce those who accept it to make a rush for all the profit they can squeeze out of the earlier years, so that they may bequeath extremely little for compulsory sale at the finish.

It is impossible to regard this seven years limit for a natural industrial operation except in one of two lights. Either it was thought that the Electric Light was sure of such a splendid, instant, and universal success that investors would recoup themselves for their outlay, and retire smiling in the short space of seven years; or else that the condition was so outrageously discouraging that the Electric Light would be snuffed out once and for all. Whichever of these hypotheses we choose to adopt, the Board of Trade is seen in a very discreditable attitude; and what we are anxious to point out now is that the attitude has in no way changed. Nearly or remotely, the property of this new industry is to be handed over to local bodies whether the owners like it or not, and at a figure which must in any case tell most injuriously both on their interests and on those of the public, who are sure to be badly served in the closing years of an expiring business. The bogey which has lately haunted the Board of Trade is the "creation of fresh vested interests;" and its aspect is so appalling that rather than create any more interests that are "vested" every interest whatsoever may in future be stripped naked. Some people are talking of land just now as if when it belongs to a landlord it is "national property," but when it belongs to a peasant it is the peasant's own; and, similarly, the Board of Trade seems to argue that when an industrial undertaking remains in the hands of private individuals it is criminal; but transferred to the members of a parish vestry it becomes respectable. We have had plenty of experience of vested monopolies, and by this time we ought to be able to legislate so as to safeguard ourselves against abuses in any new enterprise proposed to be started. But to attempt this by prospective confiscation will result not only in getting rid of the shadow, but in destroying the substance as well.

In respect to the length of life of the provisional order there is not much difference between the Government Bill and the Bill introduced by Viscount BURY; but the terms of purchase make all the difference. As to this the Board of Trade is still

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impenitent. Lord GRIMTHORPE'S description of that part of the 27th Clause which the Government would still leave operative is by no means a caricature. A corporation of any town is to be allowed to buy a going concern for something less than it was worth from those who had had the risk of starting it and keeping it going. In support of that proposition Lord GRIMTHORPE remarked that he had heard nothing "except that the corporations would like it." "It was uncertain whether electric lighting companies would be successful or not; nevertheless the House was asked to give corporations the opportunity of playing the game of 'Heads I win, tails you lose' with those companies. If the companies paid and became prosperous, the corporations would buy them; if not, they would leave them alone." His lordship expressed an opinion that to give municipal bodies a right which not even the State had ever before enjoyed would, instead of encouraging the development of the Electric Light, only bring into existence financially weak and incompetent companies. We entirely agree with Lord GRIMTHORPE, and we feel confident that the House of Lords, if it consents to a limitation of the term of years, will insist that the condition of transfer shall be, as set forth in Lord BURY'S Bill, a fair price for the business as "a going concern," and not at an auctioneer's valuation of old stores.

CORRESPONDENCE.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Prof. Thompson does his best to prevent this discussion from becoming useful from a scientific or practical point of view. His last letter contains nothing of scientific interest, and might, therefore, have been left without an answer were it not for the fact that it contains a misrepresentation of the remarks I made in my last letter to you. Prof. Thompson seems extremely anxious to prove to you that I have "relaxed," as he calls it, on the question of critical speed, and in the endeavour to prove this he goes so far as to distort my remark ("that I prefer to call the proper working speed that speed at which the magneto series machine becomes self-regulating") into an admission that a dynamo which is partially self-excited can have a critical speed! I said nothing of the kind, and to prevent any possibility of misunderstanding I again repeat that no motor and no dynamo which is not wholly self exciting can have a critical speed. It is equally incorrect of Prof. Thompson to say that my attack on the theory of the self-regulating motor is outside the points of correction about which he wrote. On the contrary, in the review of his book I called attention to the unsatisfactory way in which the problem of self-regulating motors had been treated. The introduction of the term critical speed was a by issue, and, moreover, any electrician could understand from the general sense of my remarks what I meant by this term. It is strange that Prof. Thompson should have failed to grasp my meaning; at any rate he dropped the main question concerning the value of his theory of self-regulating motors, and began the squabble whether one thing or another should be called critical speed. As I am desirous that this discussion should be of practical value (and should not be merely a dispute) I brought it back in my last letter to the real point at issue, Can a constant current motor, constructed on the basis of the formulæ given in Prof. Thompson's book, be made self-regulating? I think I have proved in my last letter that it cannot. It is useless for Prof. Thompson to shelter himself behind his friends Profs. Ayrton and Perry. Whatever those gentlemen may have done or may not have done, it is certain that they did not write Prof. Thompson's book. I suppose he, as the author, is responsible for every line in the book. Now, I have shown him, by common sense arguments in my letter a fortnight ago, that a page or so in that book is hopelessly wrong. If he can refute my arguments I am ready to be convinced. But let me ask him not to refer me to page so-and-so and formula so-and-so of his book. One can prove almost anything by a skilful manipulation of algebra—I can hardly call it mathematics—but if a thing cannot be reconciled with common sense no amount of mathematical symbols will convince me. I have given you a logical sequence of common sense arguments. Let Prof. Thompson, if he can, take them up one by one and prove them wrong. If, instead of doing this, he persists in addressing you in the vigorous but somewhat irrelevant manner he has hitherto employed, or if he passes this letter over in silence, I shall take the liberty of adhering to the opinion expressed in my review, that his chapters on motors require considerable improvement before they can be of any practical use, and I shall not further trouble you.—Yours, &c., THE WRITER OF THE REVIEW.

MISTAKES IN ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In my article on p. 347 of the present volume I particularly avoided committing myself to any particular theory of electricity, as I wished my remarks to be applicable to either theory. That there are two distinct kinds of electrification is simply an experimental fact. The two fluid theory accounts for this by assuming two distinct kinds of electricity; the one-fluid theory by assuming an excess or defect of electricity of one kind only. Personally, I decidedly prefer the latter, as being simpler; but I am not aware of any objection that can be brought against the two-fluid theory except its want of simplicity.

In reply to Mr. Johnstone's question about the repulsion between two electrified pith balls, I believe the repulsion to be effected by the medium between them being thrown into a state of stress, for the only alternative would be a direct action at a distance of which I am unable to form any mental representation. I must apologise for taking up your space with a personal "confession of belief," but unfortunately Mr. Johnstone's questions were so worded as only to leave me a choice between doing this and leaving them unanswered.

If we understand by "a substance" whatever occupies space, I do not think there is any experimental evidence to show that electricity is not "a substance." By matter we usually understand "a substance," which has inertia and the property of self-attraction according to the Newtonian law. The latter property is certainly not possessed by electricity, and there is no experimental evidence which would lead us to believe that electricity has inertia.—Yours, &c,

G. W. VON TUNZELMANN.

ELECTRIC v. OIL LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: A letter has appeared in one of your contemporaries on the above subject on the mis-quotation of some remarks made by me during the discussion on the recent paper at the Society of Arts. As the matter is of considerable public interest may I be permitted to lay before your readers what I really did say, and supplement this by my reasons, which, owing to the lateness of the hour, I was unable to give at the time of the discussion.

Following Mr. Wigham, who said gas could easily have beaten the electric light if he had been allowed to exhibit his double quadri-form of arrangement, I said that the comparative tables of cost given in Mr. Edwards's paper on lighthouse illuminants were hardly fair to the electric light, as they were made out on the supposition that an electric light of enormous candle-power, twenty times as powerful as that given by the 108 ring gas burner, must be used at all times, whether such an enormous light be required or not. I said that by proper arrangement an electric light could be furnished for lighthouse purposes which could be easily adjusted so as to give a sufficient light for ordinary clear weather, but which could be increased to any desired extent up to and even exceeding the enormous lights shown at the

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Foreland, and that the result of this modification would be, that whereas the lighthouse illuminants report shows that the electric light costs two and a half times as much as oil does, it need only cost one and a half times as much as oil. The report on lighthouse illuminants to which I refer estimates the cost of an electric light station with single light, having double power for fogs, at £17,749, and the cost of maintenance at £1,927 per annum, whereas the corresponding figures for an ordinary first order oil lighted tower are £8,064. 18s. 3d., and maintenance £724. 4s. 7d. per annum. I propose to reduce the maintenance of the electric lighting station from £1,927 to £1,100 first, by providing for ordinary lighting in clear weather a group of fourteen 50 candle-power incandescent lamps, arranged in a close cylinder and not occupying a greater space than the present Douglass six-wick burner. For thick weather I propose to substitute a powerful direct current arc light, the full advantage of which could be best obtained by using a catoptric arrangement instead of the dioptric one hitherto employed for alternating current lamps. This catoptric arrangement would necessitate a revolving or partly revolving light, and as electricity is most likely to be used on headlands or the main land the beam need not revolve or oscillate through the entire circle. I know there is no difficulty in working out the practical details of such an arrangement as I have here briefly sketched out. The electric current for the incandescent lamps or for the large arc lamps can be supplied with the greatest certainty and steadiness from accumulators, which could be charged by a comparatively small combined steam engine and boiler, or, where gasworks are accessible, by means of a gas engine. In this way the extremely heavy charges of £800 a year for wages, coke, oil, and carbons, as estimated in the report, might be reduced fully one-half. The first cost of the plant, hence the charge for depreciation and renewals, would be greatly reduced. I will not occupy more of your valuable space by going into details. I think I have said sufficient to show that a strong case may be made out for the economy as well as the efficiency of electricity employed as a lighthouse illuminant.—Yours, &c.,

R. E. CROMPTON.

Mansion House-buildings, London, E.C., 1st April, 1886.

PARALLEL DISTRIBUTION BY TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Although we consider the newspaper discussion in reference to Messrs. Zipernowsky, Deri and Blathy closed as far as we are concerned, we cannot allow the claims described in their letter of the 18th ult. to pass without protest, and we declare for the last time that we shall not allow anyone to employ secondary generators or transformers of any model or under any conditions for the purpose of distributing electrical energy.—Yours, &c,

L. GAULARD,
J. DIXON GIBBS.

18, Warwick-street, Regent-street,
London, April 7th, 1886.

ELECTRICAL GOVERNORS FOR CONTROLLING THE SPEED OF MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The electrical governor for controlling the speed of motors which is figured and described on page 407 of the last number of your journal is similar to those employed in the motors which drive the transmitters of my type printing apparatus, and were exhibited at the Crystal Palace Electrical Exhibition by the Exchange Telegraph Company long before the date of Prof. Jenkin's patent.—Yours, &c.

F. HIGGINS.

THE DIGNITY OF SCIENTIFIC DISCUSSION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter on this subject in your last week's issue is, I think, a little hard on the members of the Society of Telegraph Engineers, and still harder on the Society itself. Scientific discussions should, no doubt, always be dignified; but we know very well they are not so invariably, any more than are theological or political discussions when opinions are strong and tempers warm. If the society in question is exceptional in any way, it is chiefly in being peculiarly tolerant of the idiosyncrasies of its members and visitors. This amiable weakness is at all events better than dulness. Then, again, the discussions, although ostensibly scientific, are not on all occasions really so; and when the subject is closely associated with the pockets of promoters, advisers, or directors—or inventors who hope to become such—it is not to be expected that the unruffled solemnity of a judicial assembly, wholly impartial and disinterested, will be rigorously maintained. I often enjoy my evening at this society, rarely at any other.—Yours, &c.,

QUIZ.

7th April, 1886.

OLD SPECIFICATIONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following is a copy of a curious specification, dated 1872, that I happened to come across during a perusal at the Patent Office, and which may interest your readers:—

"My invention relates to the employment of an electrical conductor, fixed in the inner soles of boots, shoes, or slippers, or in clogs, for the purpose of driving away diseases, preventing epidemics, fever, small pox, or other contagious diseases, and dispelling noxious vapours.

"The electrical conductor is made of small, thin oblong pieces of zinc fixed in the upper soles of boots, shoes, or slippers, or in clogs. One of these oblong pieces of zinc is fixed in the front part of the upper sole, and the other in the heel part, being distinct one from the other. Copper or silver wires are placed lengthwise, and in rows, on the zinc pieces, and rest on them. The wires being in contact with the zinc cause an electrical current to be set up, and the electricity emanating from the body escapes by the wires which pass through the sole, coming out at the toe and heel respectively of the boot, shoe, slipper, or clog, thus producing a preventive force, and gradually and silently discharging from the body any excess of electric fluid, and causing a healthy action in a mild and continuous form."

The lady who filed the above has evidently not experienced the unpleasant consequences of completing a circuit through the sole of one's boot by way of an obtrusive nail.—Yours, &c.,

N. G. T.

4, Queen Victoria-street, London, E.C.,
April 2nd, 1886.

WHAT IS ELECTRICITY?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I promised to write to you on the subject of air in the lungs being the source of the supply of electricity in the human body, but before entering on this subject it is necessary to refer to some facts which throw light on the nature of electricity, and establish the accuracy of the conclusion I drew from the results of experiments on electricity which you published in 1882 (Vol. IX., page 63), namely, that electricity is a kind of matter which, although it does not gravitate, yet it seems to be the medium through which the law of gravitation acts on common matter.

1. Prof. Dewar has proved that oxygen gas is a transparent colourless fluid when exposed to a temperature of −130°C., and under a pressure of between 80 and 100 atmospheres, and also that liquid oxygen does not act on sodium, potassium, phosphorus, hydrogen, and other reagents.

2. MM. Hautefeuille and J. Chappius proved by experiments that ozone at the temperature of −23°C., and under a pressure of 75 atmospheres, is a liquid of azure blue colour.

3. All the modern books on chemistry assert that ozone is condensed oxygen.

4. Prof. Dewar found that the low temperature of −130°C. and presence of 80 to 100 atmospheres was incapable of con-

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densing oxygen into ozone. Therefore something still more powerful is required in order to condense oxygen into ozone.

5. According to all modern books on chemistry, three volumes of oxygen gas are condensed into two volumes by their conversion into ozone, namely, that "ozone is oxygen existing as a triatomic molecule." Is this the truth? Yes; but it is not the whole truth. It takes something more than oxygen to make ozone; but this something is not allowed to have an existence according to books on chemistry.

6. When a frictional electric machine is set in motion the peculiar smell which arises is caused by the free electricity acting on the oxygen of the air, and converting it into ozone. And when scientists wish to make ozone in considerable quantity they pass oxygen gas through a tube which is kept electrified positively, namely, at that which is called a high potential, and the gas which goes in at one end of this tube as oxygen comes out at the other end in the form of ozone. In other words, a supply of electricity is required to condense oxygen into ozone.

7. If ozone gas be shaken within a glass vessel containing some powdered glass the electricity which the oxygen had absorbed to convert it into ozone leaves the ozone and goes into the powdered glass, and the ozone expands into and becomes oxygen gas. This process of making a portion of oxygen gas to alternately condense into ozone and again expand back into oxygen by alternately adding and subtracting the necessary quantity of electricity, may be carried on indefinitely; in other words, we can make ozone synthetically by adding an element to oxygen, and we can decompose ozone analytically by subtracting the said element. Yet, according to all the books on chemistry hitherto published, the element in question is not granted to have any existence. It is looked upon as being merely a mathematical quantity.

8. Look, now, at the enormous difference there is between oxygen gas condensed into ozone by means of electricity and oxygen gas converted into a liquid by the low temperature of $-130°$ C., and a pressure of from 80 to 100 atmospheres. The oxygen condensed by the means of adding electricity acts with enormously increased powers on all the ordinary reagents, and it acts so powerfully on such substances as vulcanised india rubber that if a tube of it be used to pass ozone gas through, the ozone soon destroys the tube; but oxygen alone cannot do this, and when oxygen is condensed into the liquid state by low tempararture, combined with enormous mechanical pressure, it loses all its power to act on the common reagents on which it acted so well when in the gaseous state. Why is this? When oxygen is condensed into ozone it is by means of electricity added to it; whereas when oxygen is converted into a liquid by low temperature and great pressure there is good reason to believe that the amount of electricity which the oxygen held in the latent form, while it was in the gaseous state, is crushed out of it in order that the oxygen might go into the liquid state, and that it is the reduced quantity of electricity within the liquid oxygen which makes it incapable of acting on the common reagents. Although it is undoubtedly the extra amount of electricity which becomes latent within oxygen and converts it into ozone, and gives the latter the increased power of acting on reagents, yet scientists will not admit that ozone is a compound of electricity and oxygen. Their theory which asserts that electricity is a nonentity is contradicted by the foregoing facts.

Maxwell wrote in his "Elementary Treatise on Electricity," page 8, "The analogy between temperature and potential must not be assumed to extend to all parts of the phenomena of heat and electricity." . . . "We must remember that temperature corresponds to a real physical state, whereas potential is a mere mathematical quantity, the value of which depends on the point of reference which we may choose. To raise a body to a high temperature may melt or volatilise it. To raise a body, together with the vessel which surrounds it, to a high potential produces no physical effect whatever on the body."

Is this true? In order to convert oxygen into ozone, the tube through which the oxygen passes requires to be kept at a high electric potential, and it is because it is so kept that the oxygen passing through the tube absorbs electricity, and the oxygen is thereby converted into ozone, which fact is the very opposite of Maxwell's statement, that "a high electric potential has no physical effect on the body," the oxygen.

Although electricity may not gravitate, yet it has the power of causing common matter, such as oxygen, to cohere and condense so that three volumes of oxygen are crushed into two volumes, which we call ozone.

There is another interesting matter in connection with this subject. When MM. Hautefeuille and Chappuis attempted to condense ozone gas into the liquid form, they found that the ozone exploded in the glass tube they were condensing it in, when the temperature was allowed to rise higher than $-23°$ C., and at the time the explosion occurred a flash of yellowish light appeared within the tube. These scientists did not attempt to explain these phenomena; but there can be only one cause for the explosion, namely, the sudden decomposition of the ozone. Its latent electricity having suddenly left it, the two volumes of ozone would instantly become three volumes of oxygen, hereby producing the explosive force. Now arises the question, What induced the latent electricity to leave the ozone? As the rise of temperature was the primary cause of the explosion, it must have been the increased quantity of heat within the tube which attracted the latent electricity and took it away from the ozone, and, if so, then we know that it must have been the union of the extra heat with the latent electricity which produced the flash of light within the tube.—Yours, &c.,

JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, April 1, 1886.

THE COMPANIES AND LORD RAYLEIGH'S BILL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following is a copy of a letter sent by me to those interested in Electric Light Work:—

Mansion House-buildings, London, E.C.,
April 1, 1886.

DEAR SIRS: No doubt your attention has been called to *The Times* leading article of March 29 on the subject of Lord Rayleigh's Bill to amend the Electric Lighting Act. In that article several statements are made which in my opinion give an entirely false idea of the present position of the electric lighting industry in this country.

At the present moment I think that everyone in the trade should do what he can to assist to strengthen Lord Rayleigh's hands. I, for one, wish to do so by giving him trustworthy information as to the present position of the trade.

I am aware that some of the questions put below are of a somewhat delicate nature. I therefore leave it to you to answer them or not, as may suit the convenience of your firm, it being understood that my sole object in asking for this information is to use it for the benefit of the trade. Bearing this in mind, I should be obliged, if you think fit, to answer the whole or part only of the following questions:—

1. Has your business connected with electric lighting and electric transmission of power increased during the eighteen months ending April 1, 1886?

2. If so, what proportion of your orders has been for foreign countries and the colonies, and what proportion for home consumption?

3. What number of hands do you consider find employment at your works, or in the pay of your agents in the United Kingdom in the work of electric lighting and transmission of power?

4. Do you consider that the relaxation of the present legislative restrictions on house to house electric lighting would result in an increase of general business?

5. Do you think it advisable that the trade should act as a united whole to protect its interests in the Committee Rooms of the Houses of Lords and Commons by employing counsel, &c.?

6. If so, will you name the maximum amount you are prepared to give towards a guarantee fund to meet the necessary expenses?

I remain, yours faithfully,

R. E. CROMPTON.

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TELEGRAPHS OF THE WORLD.

The following Table has been compiled from "The Statesman's Year Book for 1886," edited by J. Scott Keltie. Macmillan and Co.—[Ed. *E.*]

State.	Minister of Posts and Telegraphs.	Year of Completed Statistics.	Number of Offices.	Miles Line.	Miles Wire.	Number of Messages.	Receipts.	Expenses.	Money Statistics in
Austria	... ...	1883	2,903	23,630	61,310	6,683,056	4,053,360fl.	3,646,005fl.	Florins
Hungary	... ...	1883	1,250	10,082	36,755	3,487,838	1,766,250fl.	1,759,35[illegible]fl.	,,
Bosnia and Herzegovina	... ...	1883	90	1,730	...	296,962	...	...	...
Belgium	M. J. H. Vandenpeereboom	1884	886	3,749	17,587	6,788,071	2,637,074fr.	343,532fr.	Francs
Denmark	... ...	1883	State 152 Ry. Co. 171	2,360	6,532	1,297,434	£48,454	£66,659	£
France	M. E. A. F. Granet	1883	7,523	56,545	205,470	29,452,708	Deficit.	...	...
Germany	... ...	1884	12,258	49,728	180,000	18,849,855	...	...	...
Gt. Britain & Ireland	... ...	1885	6,023	28,500	158,568	33,278,459	£1,755,118	£1,730,980	£
Italy	... ...	1884	State 1,848	17,816	...	6,778,717	10,971,741 lire	10,233,765 lire	Lires
Netherlands	... ...	1884	251	2,838	10,318	3,320,869	£86,792	£148,879	£
Portugal	... ...	1883	237	3,045	7,257	1,727,293	...	...	...
Russia	... ...	1883	2,957	65,394	146,690	10,222,139	Surplus £290,459	...	...
Spain	... ...	1883	...	10,733	26,160	3,019,831	...	...	...
Sweden	... ...	1884	...	4,102	13,044	178,959	...	...	...
Switzerland	... ...	1884	1,288	4,30[illegible]	10,386	2,942,767	£102,227	£93,770	£
Turkey	... ...	1884	464	14,617	26,060	...	...	...	...
Argentine Republic	... ...	1885	...	11,730	21,071	(1883) 496,726	...	...	...
Brazil	... ...	1885	159	5,811	9,560	(1883-4) 331,884	...	...	...
Canada	... ...	1883	2,259	23,320	...	...	...	...	...
United States	... ...	1884	W.U. 13,761†	145,037	450,571	42,076,266	Profits $6,610,426	...	Dollars
Egypt*	... ...	1885	...	2,701	5,221	...	...	...	...
India	... ...	1884	(1883) 349	23,341	68,694	1,837,048	£522,570	£669,239	£

* The Eastern Telegraph Company have a line to Cairo 455 miles in length. † Other companies 18,963 miles.
12 Florins = £. 25.25 Francs = £. 25.22 Lire = £. 4.86 Dollars = £.

ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 415.)

The same objection need not apply to Clausius' theory, for substituting the value of f belonging to his theory, the kinetic energy equals

$$(\tfrac{1}{2}m + \alpha e^2)q^2 + (\tfrac{1}{2}m' + \beta e'^2)q'^2 + \kappa ee'\frac{qq'\cos\epsilon}{r},$$

so that the kinetic energy will be always positive if

$$(\tfrac{1}{2}m + \alpha e') \quad (\tfrac{1}{2}m' + \beta e'^2) > \frac{\kappa^2 e^2 e'^2 \cos^2\epsilon}{4r^2}.$$

This condition will evidently be satisfied if

$$\alpha\beta > \frac{\kappa^2}{4},$$

and this relation does not involve the electrification. We cannot assume that we can make r so small that this condition is not satisfied, for r has a minimum value depending upon the shape and size of the electrified bodies. For example, if these are spheres, r cannot be less than the sum of their radii. On the other hand, α and β may be functions of the sizes of the electrified bodies, and the geometrical relations may be such that the condition written above must be always satisfied.

Physical reasons why the force between two electrified bodies should depend on their velocities and accelerations.

If we assume Maxwell's hypothesis that a change in the electric polarisation produces the same effect as an electric current, then we see that the kinetic energy of an electrified body must be different from the kinetic energy of the same body moving at the same rate but not electrified. For let us suppose that we have an electrified body at rest, and consider the amount of work necessary to start it with a velocity q. It is evident that it will be greater than when it is not electrified, for when it is electrified and in motion the electric polarisation in the surrounding dielectric will be in changing, and so in addition to starting the body with a velocity q we have, if Maxwell's hypothesis be true, to establish what is equivalent to a field full of electric currents. The production of these currents of course requires work, so that more work is required to start the body with a velocity q when it is electrified than when it is not; in other words, the kinetic energy of a moving electrified body is greater than that of one not electrified, but under similar conditions as to mass and velocity. In fact in this case electricity behaves as if it possessed inertia.

In a paper published in the *Philosophical Magazine*, April, 1881, I have shown that the kinetic energy of a charged sphere of radius a and mass m moving at a velocity q

$$= \tfrac{1}{2}mq^2 + \tfrac{2}{15}\frac{e^2\mu}{a}q^2,$$

where μ is the magnetic permeability of the surrounding dielectric and e the charge of the sphere. If there are two spheres in the field, then I have shown in the same paper that the kinetic energy

$$= \tfrac{1}{2}mq^2 + \tfrac{2}{15}\frac{\mu e^2}{a}q^2 + \tfrac{1}{2}m'q'^2 + \tfrac{2}{15}\frac{\mu e'^2}{a'}q'^2 + \tfrac{1}{3}\frac{\mu e e'}{R}qq'\cos\epsilon,$$

where corresponding quantities for the two spheres are denoted by plain and accented letters. We see from this expression that the forces between the spheres are exactly the same as those given by Clausius's formulæ. It would not, however, be legitimate to go and develop the laws of electro-dynamics from this result in the way that Clausius does, as Clausius's conception of an electric current does not accord with that of the displacement theory. We may remark that in this case the part of the kinetic energy due to the electrification is always positive.

On theories which are based on dynamical considerations, but which neglect the action of the dielectric.

F. E Neumann* was the first to develop a theory founded on the principles of the Conservation of Energy. His theory was based upon the assumption that two elements of circuit ds, ds', traversed by currents ι, ι' possess an amount of energy equal to

$$A^2\frac{\iota\iota'\cos\epsilon}{r}ds\,ds',$$

where A is a constant which depends upon the unit of current, r is the distance between the elements, and ϵ the angle between their directions. F. E. Neumann showed that this assumption leads to the same law of force between two closed circuits as that given by Ampère, and also explained by means of it the induction of electric currents. Von Helmholtz† has investi-

* "Die mathematischen Gesetze der inducirten electrischen Ströme," *Schriften der Berliner Academie der Wissensch*, 1845.

† "Crelle," LXVII., p. 57; *Gesammelte Werke*, Vol. I., p. 545.

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gated the most general expression for the energy possessed by two elements of current which is consistent with the condition that the force between two closed circuits should be the same as that given by Ampère's theory. We shall consider this theory in detail, as it includes all theories of this class, and we shall wish to refer to it when we come to discuss the relative methods of the various theories. Von Helmholtz begins by showing that the most general expression for the energy of two elements of circuit consistent with Ampère's laws for closed circuits is

$$\tfrac{1}{2}\frac{A^2 \iota\iota'}{r}\{(1+k)\cos\epsilon + (1-k)\cos\theta\cos\theta'\}\,ds\,ds',$$

where θ and θ' are respectively the angles ds and ds' make with the line joining the elements, k is a constant, and the other symbols have the same meaning as before.

Let us call this quantity T; then we know that T denotes the existence of a force dT/dr or

$$-\tfrac{1}{2}\frac{A^2\iota\iota'}{r^2}\{(1+k)\cos\epsilon + (1-k)\cos\theta\cos\theta'\}\,ds\,ds'$$

along r, and a force $-dT/rd\theta$ at right angles to r in the plane of ds and r, and in such a direction that it tends to diminish θ; this force equals

$$\tfrac{1}{2}\frac{A^2\iota\iota'}{r^2}(1-k)\left(\sin\theta\cos\theta' + \cos\theta\sin\theta'\frac{d\theta'}{d\theta}\right);$$

and since

$$\frac{d\theta'}{d\theta} = \cos\eta,$$

where η is the angle between the plane containing r and ds and that containing r and ds', the transverse force

$$= \tfrac{1}{2}\frac{A^2\iota\iota'}{r^2}(1-k)\{\sin\theta\cos\theta + \cos\theta\sin\theta'\cos\eta\}.$$

We see that these forces will coincide with those assumed in Kortewegs's theory if the quantities a, b, c, d, which occur in that theory, have the following values :—

$$a = -A^2$$
$$b = -\tfrac{1}{2}(1-k)A^2$$
$$c = \tfrac{1}{2}(1-k)A^2$$
$$d = \tfrac{1}{2}(1-k)A^2.$$

So that whatever be the value of k, these quantities satisfy the condition

$$2a + b + c - 2d = -3A^2.$$

According to Stefan, it is necessary if two circuits have a potential that

$$2a + b + c - 2d = 0.$$

But Stefan did not consider the couple exerted by one element of circuit on another. The couples acting on the element ds' will be as follows. There will be a couple tending to increase θ', *i.e.*, a couple whose axis is at right angles to both ds' and r, equal to $dT/d\theta'$, *i.e.*, to

$$\tfrac{1}{2}\frac{A^2\iota\iota'}{r}\{(1+k)\sin\theta\cos\theta'\cos\eta - 2\cos\theta\sin\theta'\},$$

and another couple tending to increase η, *i.e.*, a couple whose axis is along the line joining the elements equal to $dT/d\eta$, *i.e.*, to

$$-\tfrac{1}{2}\frac{A^2\iota\iota'}{r}(1+k)\sin\theta\sin\theta'\sin\eta.$$

We see that these will agree with the couples in Korteweg's theory of

$$f = -\frac{A^2}{r};\quad g = -\tfrac{1}{2}A^2\frac{(1+k)}{r};\quad h = \tfrac{1}{2}A^2\frac{(1+k)}{r}.$$

Let us return to the consideration of the energy of the circuits, and suppose that, instead of currents flowing along linear circuits, we have a distribution of them throughout space. If u, v, w be the currents in the element dx, dy, dz, then the part of the energy contributed by this element will be

$$-A^2\{Uu + Vv + Ww\}\,dz\,dy\,dz,$$

where

$$U = \tfrac{1}{2}\iiint\left\{(1+k)\frac{u}{r} + (1-k)\frac{x-\xi}{r^2}\{u(x-\xi) + v(y-\eta) + w(z-\zeta)\}\,d\xi\,d\eta\,d\zeta\right\}$$

with symmetrical expressions for V and W, where

$$r^2 = (x-\xi)^2 + (y-\eta)^2 + (z-\zeta)^2.$$

We may write the expressions for U, V, W in the form

$$U = \tfrac{1}{2}(1-k)\frac{d\psi}{dx} + \iiint\frac{u}{r}\,d\xi\,d\eta\,d\zeta$$

$$V = \tfrac{1}{2}(1-k)\frac{d\psi}{dy} + \iiint\frac{v}{r}\,d\xi\,d\eta\,d\zeta$$

$$W = \tfrac{1}{2}(1-k)\frac{d\psi}{dz} + \iiint\frac{w}{r}\,d\xi\,d\eta\,d\zeta,$$

where

$$\psi = \iiint\left(u\frac{dr}{d\xi} + v\frac{dr}{d\eta} + w\frac{dr}{d\zeta}\right)d\xi\,d\eta\,d\zeta$$

If u, v, w are the components of the ordinary conduction current, e the volume density of the free electricity, then

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = -\frac{de}{dt};$$

and if l, m, n, be the direction cosines of the normal to a surface at which the currents become discontinuous, σ the surface density of the electricity on this surface, then

$$l(u-u^1) + m(v-v^1) + n(w-w^1) + \frac{d\sigma}{dt} = 0.$$

Remembering these equations, ψ may be transformed into

$$\iiint r\frac{de}{dt}\,dx\,dy\,dz + \iint r\frac{d\sigma}{dt}\,ds;$$

or if ϕ denote the electrostatic potential of the free electricity, we see

$$\psi = -\frac{1}{2\pi}\iiint\frac{1}{r}\frac{d\phi}{dt}\,dx\,dy\,dz.$$

Substituting the value of ψ we find

$$\nabla^2 U = (1-k)\frac{d^2\phi}{dx\,dt} - 4\pi u,$$

$$\nabla^2 V = (1-k)\frac{d^2\phi}{dy\,dt} - 4\pi v,$$

$$\nabla^2 W = (1-k)\frac{d^2\phi}{dz\,dt} - 4\pi w.$$

We also see that

$$\frac{dU}{dx} + \frac{dV}{dy} + \frac{dW}{dz} = -k\frac{d\phi}{dt}.$$

In order to get the equations connecting the electromotive force with the variation of the electrodynamic potential, Neumann made use of Lenz's law, and assumed that, since by that law the electromotive force tending to increase the current in an element of circuit moving with a velocity w in the direction s would be of the same sign as

$$-Xw,$$

where X is the force along s on the element per unit of length per unit of current flowing through it, it was actually equal to this quantity multiplied by a constant c, *i.e.* to

$$-cXw;$$

but if $Ti\,ds$ be the energy of the element of current whose length is ds, and current strength i,

$$X = \frac{dT}{ds},$$

and

$$w = \frac{ds}{dt};$$

so that the electromotive force per unit of length of the element

$$= -c\frac{dT}{ds}\frac{ds}{dt}$$

$$= -c\frac{dT}{dt}.$$

Von Helmholtz has shown that it follows from the principle of the Conservation of Energy that if the energy in the elements dx, dy, dz, traversed by currents u, v, w, be

$$A^2(Uu + Vv + Ww)\,dx\,dy\,dz,$$

then the components of the electromotive force parallel to the

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axes x, y, z respectively, due to the variation in the electrodynamic potential, will be

$$-A^2\frac{dU}{dt}, \quad -A^2\frac{dV}{dt}, \quad -A^2\frac{dW}{dt};$$

the free electricity produces an electromotive force whose components are

$$-\frac{d\phi}{dx}, \quad -\frac{d\phi}{dy}, \quad -\frac{d\phi}{dz},$$

so that the total electromotive force parallel to x, y, z

$$= -\frac{d\phi}{dx} - A^2\frac{dU}{dt}.$$

(To be continued.)

CANTOR LECTURES.

Professor Forbes delivered the first of a series of six elementary lectures on Electricity in the rooms of the Society of Arts, John-street, Adelphi, on Saturday last. He said: The work of the philosopher in studying the phenomena of nature is accomplished by the aid of either observation or experiment. In the science of astronomy we can only wait, watch, and observe the signs and symbols which nature makes to us, and interpret the language in which she speaks. In the realm of electricity, however, we cannot depend much upon observation; and it is only in the laboratory, by patient experiment, that most of the secrets of electricity are evolved. With the lightning flash, the aurora, and the attraction of the compass needle, almost the whole list of facts which can be learned in connection with electricity and magnetism have been enumerated; and it is in the laboratory that we must learn how varied are the phenomena, and how fruitful is the application of this science, while at every step we find a new pleasure in receiving answers to our questions. The highest delight of the true philosopher is in seeking out new facts, and the chief charm in electricity to the true student is in grasping the innumerable phenomena which are presented to his sense, and co-ordinating and arranging those facts until he finds that a few general laws govern the whole of the diverse forms under which this protean agent is seen to manifest itself. It will be my object in this course of lectures to lay before you simply the fundamental phenomena of this comparatively new but useful servant of ours, and to demonstrate experimentally the identity of the agent, however diverse may be the operations which it has accomplished.

It was my intention when first asked to give this course of lectures to drop our old friend frictional electricity altogether, but on fresh consideration I found it was impossible to give what I wanted—that is, though it may be sketchy, an account of all the important fundamental principles which govern the science. It is impossible for us to realise what we mean by potential and electromotive force unless we study frictional electricity, and it is by means of this high tension electricity that we are able to study the peculiarities of those insulating materials which we use for telegraph cables, which are required in the highest degree in the practical applications of electric lighting and transmission of power. It is only by means of high tension electricity that these phenomena can be properly studied, and that we can appreciate what is the part played by the insulating medium when electrical phenomena are being mainfested. I shall not delay long in showing you some of the very elementary principles which are necessary to make the survey of this part of the subject tolerably clear. I shall show first what is a well-known principle—a long-known power—namely, that, when I rub two materials together, such as a piece of glass and a piece of silk, they attract each other. Here I have a piece of silk suspended to the retort stand; I rub it briskly with a piece of glass, and you notice that it attracts the silk to one side, and that the brisker I rub it the more complete is the attraction. Not only is it so when it is in contact with the silk, but it will even attract it from a little distance. This is the first phenomenon that has to be grasped in electricity—namely, that two bodies when rubbed together will attract each other. I might take other materials and illustrate the primary fact, attraction, in a variety of different ways. This is easily done in many ways which are probably familiar to all of you. Here is a piece of sealing wax, and when I rub this with cat's skin I show that there is attraction between the sealing wax and the cat's skin. But I will now demonstrate to you that it is able to attract another body. I have here a piece of gilt paper rolled up in a ring, and the sealing wax will be seen to attract that gold leaf, which will be made to run over the table in whichever way I choose. [Experiment shown.] There are many other experiments which might be shown in the same way. I will now introduce to your notice this most delicate instrument which we have for detecting the presence of electricity, which is called a gold leaf electroscope. When we say a body is electrified, we merely mean that it has that peculiar property of attracting which I have shown you just now. You must not imagine that there is a material substance residing on the sealing wax or the glass rod when it is electrified, you must simply understand that it possesses this unusual property, this electrical condition. When sealing wax possesses that unusual condition —when we say it is electrified—it has the power of communicating that condition to another body which is touched with it, and this can be shown when we touch the electroscope which is before you. The result will be seen in the repulsion of the leaves of the electroscope. [Experiment.] Now this is a new fact. Here we have two gold leaves hanging within a metal jar, and they are both electrified by the same substance and they repel one another. This is the first case of repulsion that has come before you. We should find that, as a rule, there are two different kinds of electrification, and I will not delay long to point this out. At the present moment you see that the gold leaves are repelling each other with slight force. You will see, if I approach this sealing wax towards them they tend to close in. If I withdraw the sealing wax they spread out again.

With an electrified glass rod a very different thing takes place. I rub the glass rod briskly, and I approach it towards the gold leaves, and they diverge still further—that is to say, the rubbed sealing wax tends to destroy the electrification of the gold leaves; the rubbed glass rod tends to increase it. This shows us a difference in the quality of the electricity, which is developed with the sealing wax and the glass rods. And now we have found two things: that there is sometimes attraction, and there is sometimes repulsion. I pointed out to you that when the glass rod and silk were rubbed together there was always attraction, and I may state generally that when two dissimilar bodies are rubbed together there is always attraction. But we have also seen that the two gold leaves when electrified with the same kind of electricity repel each other, and in this way we are led to the general law that similar bodies similarly electrified repel each other, and bodies electrified in a different way from each other attract each other. And this, then, is what we arrive at—that if we take any two materials and rub them together the one will be electrified in one manner and the other electrified in another manner, so that they can attract each other; but if a single electrified body be taken and caused to touch different bodies the latter will repel each other, because they are electrified in the same way. Now this enables us to classify all the different bodies in a regular scale, and I have a table at my side here [A list of various substances exhibited] which is arranged in such a manner that if you rub any of these two substances together—for example, the one which is the highest on the list—it will be what we call positively electrified, and will be analogous in its behaviour to the rubbed glass, but the one which is lowest on the list will be negatively electrified in the same manner as rubbed sealing wax is. The list comprises cats' fur, polished glass, silk, woollen stuff, feathers, wood, paper, shellac, and rough glass.

Now, I draw your attention to the fact that the order in this list does depend on the character of the substance and the nature of the surface. In that table you will see that rough glass is put at the bottom and polished glass is put near the top. Now, I have a piece of glass which is half rough and half smooth. I rub these with my sealing wax as before. According to the table which we have there the smooth-polished glass comes before the silk, and therefore it should affect the gold leaves in the manner represented by positive electrification. So when I approach it thus the leaves converge. [Experiment.] I now reverse the end of the rod and rub the roughened glass, and you will see, according to the table, that the roughened glass will be negative, and the opposite of attraction will take place on the electroscope. If I rub it on the fur of the cat we shall get the effect better—so. This is a peculiarity of the surface, and it is one which we find at different stages of our investigation. We find that the surface has an influence on the character of the electrification. Thus we find that a black ribbon rubbed with a white ribbon is negative to it; we discover that a hot piece of cork rubbed against a cold piece of cork is negative to it. I point out to you the fact that in these cases where the fact of surface comes in, the material which is the best radiator of heat becomes negative to the one which is the worst radiator of heat. Black silk radiates more than white silk, a rough surface more than a smooth surface, and is negative to it. I give you this fact merely as an aid to your memory in view of what I shall have subsequently to tell you.

Hitherto I have dealt with the electrification of materials which we call insulators, which do not conduct electricity readily. If I rub a piece of brass with the cat's skin it will be found to have no influence whatever on the electroscope; but it is not because electricity is not generated in the brass; the reason is that the brass is able to conduct the electrical condition through my hand, and so over the surface of my body to the earth; and if I put the brass on a piece of sealing wax which does not conduct the electricity freely, then we shall be able to see when rubbed with the cat's skin that there is a development of electricity as shown by the divergence of the gold leaves. [Experiment shown.] I simply mention this fact, which has been carefully studied by experimenters, that we find the law of attraction between two bodies so electrified varies inversely as the square of the distance—that is, it follows the same laws as gravitation. We are accustomed to say when we electrify a body in any of these manners that the two substances which are rubbed together, after the rubbing, have different electrical potentials. I will come to speak of that presently, and a thorough understanding of it will help us vastly in our more advanced stages. I merely here remark that I can obtain a very high difference of potential by means of such machines as have been constructed, such as this apparatus, which is the well-known electrical machine of Mr. Wimshurst, by means of which we are able to get vivid sparks. I have here a very large multiple plate machine which has been kindly constructed for illustrating these lectures by Mr. Wimshurst. He has spent a great deal of time in improving the construction of machines for generating electricity. Two or three weeks ago another gentleman and myself were visiting his house, and we were struck with a magnificent machine which he had completed, which gave a larger quantity of electricity, I may say, than any machine that has hitherto been constructed. A sigh escaped me when I thought I could not produce that machine before the present audience, and without saying a word to me Mr. Wimshurst, immediately on our departure, set to work and manufactured this machine—[showing it]—which could be easily transported from his house, and it shows the outcome of a fortnight's work taken out of sleep hours. It is an act of kindness for which I cannot too heartily thank that gentleman. There is a word which I have used to you just now, and which is being continually used in connection with the application of electricity, and that is the difference of electrical potential. And this is a fitting time to say something about it. As I have been telling you, these two bodies when rubbed together

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acquire a difference of potential. What do we mean by this expression? It is a comparatively new one in scientific language, but one of the greatest importance. We know that force of gravity gives velocity to a falling body, and the body acquires energy of motion. When a body is raised from the floor on to a table it also acquires energy, although it is not in motion, because it has the power of dropping back again to the floor, and so doing work. How are we to express the energy that exists in a ball, for example, when it is on a table? It has the potency of doing work. It has what Newton called potential energy, and that expresses freely what we mean. Now, suppose a ball be thrown up into the air; at starting it gains energy—energy of motion; but gradually the energy of motion disappears and its velocity gets less and less, until at the top of its flight it has no motion at all. The whole energy of motion with which it started has been converted into energy of position, and the grand principle of the conservation of energy tells us that at any moment in the history of the universe the energy in it is the same. And this is an illustration of the conservation of energy, that the sum of the energy of motion and the energy acquired by its position is constant in the case of the ball. You see, then, what we mean by energy of position, and the energy of position is identical with what we speak of as potential energy. Now, if I have a piece of sealing wax negatively electrified, and a piece of cat's skin positively electrified, and then take any substance charged with positive electricity, and carry it from the sealing wax, which attracts it, to the cat's skin, which repels it, I am obliged to do work, just as I am obliged to do work in raising a weight from the floor on to a table; and what I mean by the difference of potential between the cat's skin and sealing wax is simply the work which I should have to do on a ball in lifting it from the sealing wax to the cat's skin. That is simply what is meant by the difference of potential between two bodies. Various instruments have been devised for measuring the difference of electrical potential. The gold leaf electroscope which we use, as being more handy and convenient in a room, does not actually measure the difference of potential, but merely serves to indicates whether there is a great difference of potential or not. The most sensible and most exact instrument we have is what is known as the quadrant-electrometer of Sir Wm. Thomson, and I believe I shall be able to show you that delicate instrument.

Hitherto I have been speaking to you about electric forces—the forces with which two electrified bodies attract or repel each other; and these forces are what we all can thoroughly understand as being forces, because we see their effects in the motion of material bodies. I am now going to bring before your notice different kinds of force which is not readily called force in the Newtonian sense of the word. The force which I am going to speak of now is usually called by the name of electromotive force. Newton called force that which causes or tends to cause motion in a body. When we have seen these attractions and these repulsions we have seen motions produced in a body. When gravity is acting on a heavy body it is tending to produce motion, although the tendency is not allowed to come into effect. In all cases of force, as Newton intended the word force to be used, motion is produced, or tended to be produced, in a body. With electromotive force this is not the case. Electromotive force is a tendency to produce a change in the electric condition of a substance. I will try and show you the production of this kind of force by its action upon a conductor. I have here two balls so connected together that they make one continuous conductor. If I were to take one or other towards the electroscope it would not show any signs of electrification; but now, when I rub this cylinder with the silk it becomes electrified in the same way. But I will not touch them, I will bring them into the neighbourhood of the two—so. This glass is positively electrified, and I say it attracts negative electricity towards itself, and repels positive electricity away. It is acting upon the electrical distribution, and I will now separate these balls, and I have no doubt that the electroscope will show that they are charged, the nearer ball with negative and the further with positive electricity. [Experiment shown.] Thus we see not only can electrification produce visible tangible effects in the way of motion on a material body, but it is able to create a motion of electricity; that if the body be positively electrified, it is able to attract the negative electricity towards itself, and to repel the positive electricity to the most distant part of the substance.

I will now show you one or two applications of this principle of induction as it is called. The first illustration may be given by showing the influence on the gold leaf electroscope. If I rub the sealing wax once more and electrify it, the sealing wax becomes negatively electrified. If I cause it to approach the electroscope the positive electricity will be attracted to the sealing wax, the negative electricity will be repelled, as you see by the movement of the gold leaves. [Shown.] On removing the sealing wax the electromotive force is removed, and the electrification returns to its normal condition. Now, I will repeat the experiment in a slightly different way, and I will connect the gold leaves with the earth by means of my finger, so that the electricity which is repelled by the sealing wax may pass to the earth instead of to the gold leaves. [Experiment.] Now it has passed to the earth, and the positive electricity is attracted towards the sealing wax, and exists in the gold leaves and their attachments. I now remove the sealing wax, and the leaves diverge by reason of the charge of positive electricity which has thus been "induced" in them. When I take a pith ball, or any light material like that, and bring an attracting substance near it, the attraction which takes place is only due to induction. The negative sealing wax will draw positive electricity towards it, and repel the negative; the positive being nearest to the sealing wax is most attracted, and, therefore, we have attraction. But when once the electrification of th sealing-wax has been communicated to the pith balls they are repelled in the ordinary manner.

I will now show you several ways in which induction can be applied. First, let me show you the electrophorous. Here is a plate of resin. I will give it a few brisk rubs with the cat's skin; it is now electrified negatively. I now place on the top of it a metal disc, like this, which touches the resin on two or three points and takes off the electricity of these points. Now, the parts which were not in contact with the brass are negatively electrified and attracting the positive electricity towards the brass, and the negative electricity is repelled through my fingers to the ground. If I now lift this it ought to be charged with positive electricity—so. I will show you a thing which can be done by means of this electrophorous. [Experiment with Leyden jar.] Having once more charged it thoroughly, I can repeat the operation which I did just now, and I can go on a great number of times. This jar is all the time accumulating a greater charge. Thus, by means of going through this operation of induction and communication, in this way I am able to give a very considerable charge to that apparatus, which is called the Leyden jar. At present it is sufficiently charged to show you how electricity is accumulated, for I am able by that means to induce electricity to a great extent. I will demonstrate to you what that general principle has led up to in the past. It has led to the construction of machines of very great simplicity and probably of great utility in the future, although we do not see exactly at present what the applications may be.

The first actual machine of the kind which was made was what was called Nicholson's doubler, which is an automatic means of increasing the charge by induction. I will not delay here with this, but simply say that this instrument was invented in 1780, and this little instrument before you is the precursor—the one which has led up to the construction of this magnificent machine (Wimshurst's presumably) which produces marvellous effects, which I will presently show you. It takes a little time to charge itself. The peculiarity of Mr. Wimshurst's machines is that they do not give us much trouble; but he has made this one not to be able to charge itself very rapidly, and it may cause us a little delay. In the meantime I will show you this apparatus, which Mr. Wimshurst has constructed to show the principle of his machine. It consists of two glass discs or spheres that rotate in opposite directions upon a spindle, and these brass wires which you see carry any electricity which may be introduced across through the disc at one part of the circumference to another part of the circumference, and there is a continual mutual induction going on between the two discs; and so by means of these brass wires the electricity which may be introduced adds this effect to the two opposite sides of the disc, and there is a greatly increased effect, so that when the induction has taken place for a few seconds we see very vividly the quantity of electricity which is produced in this very pretty little instrument, which Mr. Wimshurst calls the "electrical sprinkler." [Experiments.] Here we have a very brilliant discharge. It is very seldom that such a quantity of electricity has been generated by a machine of this kind. This machine consists of eight plates arranged in a most favourable condition, according as it has been developed by Mr. Wimshurst, and this discharge which I am showing you just now is that which shows the greatest quantity of electricity in a given time. That is, not in the form of a spark, but it gives us the largest quantity of electricity that we can get. I will now connect two Leyden jars, and then you will see that we can get a totally different effect. Let me say in regard to these Leyden jars that by connecting the insides with one pole and the outsides with another, or something equivalent to that, that I am able to accumulate in this conductor a large quantity of electricity before it is able to escape to the other conductor. These Leyden jars, as they are called, are simply accumulators of electricity, and they accumulate the electric charge. I shall begin with the poles very close together, and now the electricity cannot pass across that distance between those poles until these acquire a certain difference of potential. Consequently, in this arrangement of the experiment, what we shall see is a pause during which nothing happens; then a flash across; then a pause; then a flash across; then a pause, during which the electricity is accumulating. [Experiment.] I limit myself to about six or seven inches spark, because I do not wish to press the experiment too far. There is an experiment which I am anxious to try, but which I have not perfect confidence in; but I am in hopes that I shall be able to show it later on. I shall strain this machine to its utmost limit, and the limit will not be the strength of the machine, but that of the Leyden jar, and we may possibly break one of these Leyden jars—indeed that is very likely to be the case, but it will show you the power of the machine.

(To be continued.)

ON A NEW FORM OF STEREOSCOPE.*

BY A. STROH.

Two optical lanterns are placed side by side, as for dissolving views. Two transparencies, photographed in the same manner as if intended for an ordinary stereoscope, are placed one in each lantern, and projected on a screen in such a position that they overlap each other as nearly as possible. The picture which is intended to be seen by the right eye may be placed in the right-hand lantern, and the other in the left.

Supported by suitable framework, and in the front of the two lenses of the lanterns, is a revolving disc, portions of which are cut away, so that during its revolutions it obscures the light of each lantern alternately, or, in other words, so that only one picture at a time is thrown on the screen. A continuous change from one picture to the other is thus obtained.

In the same framework, and in convenient positions for the observers, two pairs of eyeholes are provided, one pair on either side of the apparatus. Behind each pair is also a rotating disc, and these discs are connected by suitable wheel work or driving bands with the one previously mentioned, in such a way that the three discs rotate together, and at the same rate.

* Abstract of a Paper read at the meeting of the Royal Society, April 1, 1886.

The two last-named discs are also so cut that they will obstruct the view through the right and the left eyeholes alternately.

Finally, the connection between the three discs has to be so arranged that the time of obscuring the view through the right eyeholes or the left eyeholes shall coincide with the time when the light is shut off from the right or left lense of the lanterns respectively.

It is obvious that by this arrangement an observer can only see the picture projected from the left lantern with the left eye, and the one from the right-hand lantern with the right eye.

The rotation of the discs must be of such a rate, that the alternate flashes of the right and left pictures on the corresponding eyes follow in such rapid succession that the impression made by one flash does not diminish sensibly before the next flash on the same eye is received. The number of flashes for each eye which is required to produce an apparently continuous view, without any flickering effect, is from thirty to forty per second. As the discs are so cut as to produce two flashes for the right eye and two for the left in one revolution, they must consequently be kept rotating at a rate of from fifteen to twenty revolutions per second.

The rotation of the discs is effected by a driving wheel and band, worked by a crank handle at the back of the apparatus.

The perspective effect obtained by the above arrangement is very perfect, the image of each object standing out in solid relief. Considering that by this arrangement the two eyes never see at the same time, and that each eye views its picture after the other, it is interesting to find that the persistence of vision so completely bridges over the alternate interruptions to which it is subjected as to produce the effect of a continuous view.

The advantages claimed for this form of stereoscope are, that the pictures can be enlarged to such an extent as to appear equal, or even larger than the original objects from which they were taken; and that the eyes, in looking at the pictures, are not in any way subjected to strain by lenses, prisms, or reflectors, or by the difficulty which some persons experience in getting the two pictures to superpose. For each eye views its corresponding picture in exactly the same position it would see it in if it were looking at the original, since the two pictures are practically in the same place, which is not the case in any other form of stereoscope.

Although, with the apparatus as here described, only two persons can see the pictures at the same time, it would not be very difficult to construct it so as to be available for a greater number. The side discs above described only serve to control one pair of eyeholes each, but by making them larger they would serve for two pairs each, thus accommodating four observers. By increasing the number of discs the number of observers might be increased proportionately.

PHYSICAL SOCIETY.—March 27th.

Prof. W. G. Adams, Vice-President, in the chair.

Mr. A. R. Wright was elected a member of the society.

The Chairman read a letter from Dr. Alder Wright, secretary to the Tribe Fund Committee, in which reference was made to the scientific work of the late Mr. Alfred Tribe, and an appeal made for funds to aid in the maintenance and education of his family, which, owing to his early death, had been left in straightened circumstances.

The following communications were read:—"On an Arc Lamp Convenient for Use, with the Duboscq Lantern," by Prof. S. P. Thompson. The old Duboscq lamp, though working well with a series of Grove cells, is very unsuitable for use with currents from dynamos. Prof. Thompson has employed as a substitute in the Duboscq lantern a lamp commonly known as the Belfast arc lamp. The result is all that can be desired as regards steadiness and regularity. The "focussing"—that is the adjustment of the arc so that it shall remain unchanged in position—is effected by a wheel below the lantern, which is moved by hand.

"On a Modified Maxwell's Galvanometer," by Prof. S. P. Thompson. The galvanometer consists of a light frame of copper, upon which is a coil of wire. This is suspended between the poles of a horseshoe magnet, and a piece of soft iron is placed within the coil, but free from it, which concentrates the magnetic force between the poles. The coil is suspended by two silver wires, by which it is in connection with two binding screws on the base of the instrument. This galvanometer is extremely simple in adjustment and very dead beat. It has also the advantage of being affected to an inappreciable extent by neighbouring magnets and currents, with a current in its own coils. When no current is in it is of course quite unaffected. The reading is effected by the ordinary lamp, mirror, and scale arrangement.

"On the Expansion of Mercury between 0° and −39° C.," by Professors W. E. Ayrton and John Perry. On November 14, 1885, Mr. G. M. Whipple gave the society the results of the examination of thermometers down to the melting point of mercury. There was, however, no evidence as to whether the contraction of the mercury continued uniform, as the thermometers were only compared with mercurial ones. The authors have therefore examined this point, and have made a series of comparisons of a mercurial thermometer, lent them by Mr. Whipple, with a constant volume air thermometer, both immersed in a bath of frozen mercury which was allowed to gradually become warm. The result obtained was that no certain deviation from a linear law could be detected in the expansion of mercury when temperature was measured by the increase of pressure required to keep a volume of air constant. Hence temperatures down to −39°C. may be correctly measured by a mercury thermometer, the stem of which is graduated for equal volumes.

"On the Expansion produced by Amalgamation," by Profs. W. E. Ayrton and J. Perry. It has been accidentally observed by the authors that the amalgamation of brass is accompanied by great expansive force. If one edge of a straight thick brass bar be amalgamated, it will be found that in a short time the bar is curved, the amalgamated edge being always convex and the opposite concave. The authors imagine that a similar action may be the primary cause of the phenomena presented by the Japanese "magic mirrors." Japanese mirrors are made of bronze, and have a pattern cast upon the back, and although to the eye no trace of it can be discovered upon the polished, reflective surface, yet, when light is reflected by certain of these mirrors on to screen, the pattern is distinctly visible in the luminous patch formed. In a paper before the Royal Society they have shown that this is due to the polished side opposite the thinner parts of the casting being more convex than the others, a conclusion verified by the fact that the pattern is reversed when formed by a convergent beam of light. Such a condition of things would evidently result from a uniform expansive stress taking place over the reflecting surface, the thinner, and consequently the weaker, parts becoming more convex or less concave than the others. The authors have hitherto attributed this inequality of curvature to a mechanical distortion to which the mirrors are intentionally submitted during manufacture, to produce the general convexity of the polished surface; but they now think it possible that the use of a mercury amalgam in the process of polishing may have an effect in the production of this inequality of curvature.

THE ELECTRIC LIGHTING ACTS.

Yesterday, at a large meeting of the Association of Municipal Corporations, held at Westminster Palace Hotel, the Mayor of Salford in the chair, the three Electric Lighting Bills now before the Lords were considered, and the report of the Law Committee thereon read and adopted. Sir George Morrison, town clerk of Leeds, explained that at a joint meeting of the Parliamentary and Electric Lighting Committees of Leeds it was determined to support the Government Bill, and he moved a resolution to that effect, and the meeting determined that a clause should be added to the resolution asking the Government to make the consent of a corporation a condition precedent to a provisional order being granted to a company. The resolution was seconded by the Town Clerk of Birmingham (Mr. E. Orford Smith), and supported by several representatives of large bodies. Sir George Morrison said during the discussion that had taken place an attempt had been made to saddle the failure of the electric lighting companies upon the purchase clause of the Electric Lighting Act of 1882. Several gentlemen of engineering eminence had told him that the real cause of the failure, apart from the reckless speculation which had taken place in electric lighting shares, had been the fact that electrical science itself had not yet succeeded in being able economically to supply large towns from a central power station. The borough engineer of Leeds and himself had discussed the matter, and he thought it was not impossible that other modes of power (the essential factor in all electric lighting installations) which would facilitate the use of the electric light in large towns would be available, and practically render the functions of electric-light companies worthless. The resolution was carried unanimously, and on the motion of the Mayor of Huddersfield, seconded by the Town Clerk of Longton, it was unanimously resolved that, "The town clerks of Leeds, Nottingham, and Birmingham, and representatives from the Corporations of Liverpool, Manchester, Blackburn, and Sheffield, be requested to give evidence in support of the resolution of the Association before the Lords Committee on Electric Light Bills, which sits for the first time to-day."

PARLIAMENTARY INTELLIGENCE.

HOUSE OF LORDS, FRIDAY, MARCH 26.

ELECTRIC LIGHTING ACT (1882) AMENDMENT (NO. 1) BILL.

Lord Rayleigh, in moving the second reading of this Bill [*Electrician*, 12th March], reviewed the history of electric lighting down to the passing of Mr. Chamberlain's Act of 1882, which, instead of promoting or regulating the system, had really put an end to it so far as the lighting of of towns and houses on a permanent footing was concerned. The ground of complaint against that Act was in the 27th Clause, by which local authorities had the option of compulsorily purchasing electric lighting undertakings after 21 years, and paying for the undertaking, plant, &c., only the value at the time of purchase—*i.e.*, when the machinery might be much worn or even obsolete. If the terms of purchase had been reasonable the mere shortness of time might not have constituted an obstacle in the working of the clause; but no capitalist would care to invest his money in electrical enterprises on such terms as the Act imposed. It seemed to him that there was too much jealousy at the present day of a private company making large profits. Most undertakings were more or less of a speculative character, and if some were great successes others were miserable failures, so that one ought to be balanced against the other. He admitted that in the evidence given before the Select Committee of the House of Commons some of the expert witnesses seemed to think that 21 years might suffice as a minimum; but not in conjunction with such terms of purchase at the end of the period as were embodied in the Act. To obtain some relaxation in its provisions, it was thought at first that a prolongation of the period, coupled with fairer terms of purchase, might meet the case; and this was the principle on which the second Bill (Lord Bury's No. 2 Bill) was framed. If the question were merely one of raising a large amount of capital in order to make a start once for all, such a relaxation would meet the case. But enterprise like that of electric lighting was largely experimental, and would continue to be so for many years. Large amounts of capital would not be invested in it, except slowly and gradually: and this would involve going into the

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market from time to time to obtain fresh capital. In what position would the company be to effect this object? After a considerable fraction of its time had expired it would be impossible to attract fresh capital to their enterprise. The public would not be well served during the waning years of the term, and no areas would be extended or improvements introduced. He considered that the best course was to place electric light and gas on the same footing as regards both privileges and obligations. In conclusion, he particularly deprecated any further delay in giving a fair chance to this most interesting application of modern discovery and invention for the relief of the gloom and unhealthiness of our large cities.

The Bill was read a second time.

No. 2 BILL.

Viscount BURY then moved the second reading of his Bill (the text of which we print below), which fixed the term at 42 or 63 years, at the end of which period the local authority would have to pay the price of a going concern. The Act of 1882 had made electric lighting an impossibility by frightening away investors and capitalists, who naturally declined to risk their money in a concern which might be bought compulsorily for the price of old iron at the end of 21 years.

This Bill also was read a second time.

Viscount BURY then moved that these two Bills should be referred to a select committee.

Lord HOUGHTON, on the part of the Government, admitted that some of the stringent provisions of the Act of 1882 must be relaxed. But sufficient security would have to be taken against the creation of new and perpetual monopolies. He objected to Lord Rayleigh's Bill because it would establish a new series of vested interests, and the Bill of Viscount Bury would create a more dangerous because more insidious form of monopoly. Her Majesty's Government were prepared to extend the minimum period from 21 to 30 years, and with the consent of the local authority to 42 years from the date of the concession. He suggested that these two Bills, together with the Government Bill, should be referred to a committee of the whole House rather than to a select committee.

Viscount BURY declined to adopt this course, and the discussion was adjourned until the Government Bill should be before the House.

THURSDAY, APRIL 1.

No. 3 BILL.

Lord HOUGHTON moved the second reading of this Bill, consisting of one clause extending the term of the provisional order from the Board of Trade to 30 years, and, provided the consent of the local authority was obtained, to a further period of 12 years, or with the permission of the Board of Trade for 10 years. Then, at the end of every 10 years the purchasing powers of the local authority might be exercised.

The Bill was read a second time.

Nos. 1, 2 and 3 BILLS.

Viscount BURY moved that these three Bills be referred to a select committee.

Lord HOUGHTON opposed the motion on the ground that all the technical and commercial evidence on the subject had been obtained on the Bill of 1882, and that a fresh select committee would prevent any legislation before the end of next session.

After some discussion, in which Lords GRIMTHORPE, HOUGHTON, BRAMWELL, RAYLEIGH, and Earl CAMPERDOWN took part, Earl Granville consented to the reference to a select committee, expressing a hope that it would arrive at a conclusion as soon as possible.

Electric Lighting Act (1882) Amendment (No. 2).

(Introduced by Viscount Bury.)

HOUSE OF LORDS.

An Act to Amend the Electric Lighting Act, 1882.

Whereas it is expedient to amend the Electric Lighting Act, 1882:

Be it therefore enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:

1. This Act may be cited for all purposes as the Electric Lighting Act, 1886, and this Act and the Electric Lighting Act, 1882, may be cited together as the Electric Lighting Acts, 1882 and 1886.

2. The Electric Lighting Act, 1882, is hereinafter referred to as "the principal Act," and this Act, so far as is consistent with the tenour thereof, shall be construed as one with the principal Act.

In this Act the several words and expressions to which meanings are assigned by the principal Act have the same respective meanings, unless there be something in the subject or context repugnant to such construction.

3. Section three (sub-section one) of the principal Act (1882) shall be read and have effect as if the following words, "Provided always, that where such local authority is already the holder of a license or provisional order for the supply of electricity within the area or any part of the area in respect of which the application for a license is made, the Board of Trade may, if it shall think proper, grant the license for which application is made, without the consent of the local authority," had been inserted at the end of that sub-section.

4. Section twelve (sub-section two) of the principal Act shall be read and have effect as if the following words, that is to say, "except so much thereof as relates to the use of any burner other than those such as have been provided or approved of by the undertakers," had not been inserted in that sub-section.

5. Section eighteen of the principal Act shall be read and construed as if the words "In cases in which the supply of electricity is measured by and charged for according to meter" had been inserted at the commencement of the section.

6. Section 27 of the principal Act is hereby repealed, and in lieu thereof the following provisions shall have effect; that is to say, "Where any undertakers are authorised by a provisional order or special Act to supply electricity within any area, any local authority within whose jurisdiction such area or any part thereof is situated may, within six months after the expiration of a period of forty-one years from the date of the passing of the Act confirming such provisional order, or of such special Act, and within six months after the expiration of every subsequent period of seven years, by notice in writing require such undertakers to sell, and thereupon such undertakers shall sell to them their undertaking, or so much of the same as is within such jurisdiction, upon terms of paying the then value thereof as a going concern. Such value in case of difference shall be determined by arbitration, and due regard shall be had to the nature and then condition of the buildings, works, materials, and plant of the undertakers, and to the state of repair thereof, and the suitability of the same to the purposes of the undertaking, and where a part only of the undertaking is purchased, to any loss occasioned by severance. The Board of Trade may determine any other questions which may arise in relation to such purchase and may fix the date from which such purchase is to take effect, and from and after the date so fixed, or such other date as may be agreed upon between the parties, all lands, buildings, works, materials, and plant so purchased as aforesaid shall vest in the local authority which has made the purchase, freed from any debts, mortgages, or similar obligations of such undertakers, or attaching to the undertaking, and the powers of such undertakers in relation to the supply of electricity under this Act or such provisional order or special Act as aforesaid, within such area or part thereof as aforesaid, shall absolutely cease and determine, and shall vest in the local authority aforesaid."

Building Trades Exhibition.—At the Architectural and Building Trades Exhibition, now being held at the Agricultural Hall, Islington, Messrs. Cordner, Allen, and Co. exhibit specimens of the "Byng" patent acoustic telephone and "Leo" patent line guide and insulators. The telephone is simple, and will be found useful for business premises and country mansions. They also exhibit a variety of electric bells and other instruments. Messrs. Coe and Smith send a large selection of electric bells, indicators, speaking tubes, &c., including Smith's patent pull and push for electric bells, which dispenses with the use of the spring crank hitherto used. Messrs. Eck, Callow, and Co., of Clerkenwell-green, have also an excellent display of electrical bells, testers, fire alarms, and general electrical instruments. Messrs. E. Jacobs and Co. show a "Radcliffe" silent gas engine (Wordsworth and Wolstenholme's patents). A 2 horse-power engine is shown, for which many advantages are claimed, not the least of which is that it is no infringement on previous patents.

LEGAL.

A Director's Fees.

In the Queen's Bench Division of the High Court of Justice, on Saturday, before Mr. Justice Grantham, the case of Gilman *v.* the Gülcher Electric Light and Power Company (Limited) was tried. The plaintiff, who was represented by Mr. Candy, claimed to be entitled to £220 for his attendances as director of the company. The Articles of Association provided that £1,500 should be set apart by the company for the directors, who distributed it among themselves at the rate of £250 for each director, and £500 for the chairman. But the other directors refused to sit with Mr. Gilman, and, consequently, although he presented himself, he did not attend any meeting in May, 1885, and resigned on May 28th of that year. The directors passed a resolution declaring the plaintiff not entitled to any fees for 1885; but they admitted that he was entitled to payment up to the end of 1884. The company, represented by Mr. Pyke, set up a counter claim for £100 due from the plaintiff as calls upon shares held by him in the company. There were also standing in the name of Mrs. Gilman 120 shares, upon which the plaintiff had paid some of the calls.

The judge decided that the defendants were not entitled to recover from the plaintiff the outstanding calls upon the shares registered in his wife's name; but upon striking a balance between the £70 due for fees in 1884 and the £100 due from the plaintiff upon his own shares, he found that £29 odd was due to the defendants, and he gave judgment for that sum with costs.

COMPANIES' MEETINGS & REPORTS.

Montevidean and Brazilian Telegraph Company.

The following is from the report of the Directors, which was submitted at the ordinary general meeting of the Company on the 7th inst. We are unable to add any other information, reporters not being admitted to the meeting:—The Directors regret that the percentage of gross revenue receivable from the Western and Brazilian Company again shows a serious falling off, being £1,529. 12s. 5d., as compared with £1,860 in 1884. The reduction in receipts, as the shareholders are aware, began in 1883, in which year the severe competition of the Brazilian Government land lines compelled a heavy reduction in the rates previously charged. The continued and increased reduction is attributable mainly to the great depression in business affairs which has prevailed during the year, and prejudicially affected

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the receipts of the Western and Brazilian Company in common with those of telegraph companies generally. At the same time the income of the Western and Brazilian Company has been specially affected by the exceptionally low rate of exchange which has existed, the average rate for 1885 being about 18¾d. per milrei as compared with about 21¼d. in 1884. The balance to the credit of revenue account amounts to £494. 4s. 9d., which will be absorbed in making provision for the redemption of debentures. The Directors regret that they have been unable to make further progress with the negotiations for the disposal of the undertaking to the Western and Brazilian Telegraph Company.

Eastern Extension, Australasia, and China Telegraph Company.

Report and accounts of the Directors for the half-year ended 31st December, to be submitted to the twenty-fifth ordinary general meeting, to be held at the Cannon-street Hotel, on the 14th inst., at 2 o'clock.

The gross receipts, inclusive of Government subsidies, have amounted during that period to £247,017. 6s. 4d., against £248,087. 19s. 5d., for the corresponding half year of 1884. The working and other expenses, including £27,236. 16s. 1d. for cost of repairs to cables and expenses of ships, absorb £71,473. 6s. 9d. against £79,496. 9s. 1d. for the corresponding period of 1884, leaving a balance of £175,543. 19s. 7d. From this is deducted £3,763. 2s. for income-tax, and £41,595 for interest on debentures and contributions to sinking funds, leaving £130,185. 17s. 7d. as the net profit for the half year, which, with £32,858. 6s. 11d. brought forward from the previous half year, leaves a balance of £163,044. 4d. 6d. Against this the balance of cost of the Singapore-Saigon and Penang-Rangoon cable renewals, the cost of duplicating the Victoria-Tasmania cable, and the cost of connecting and establishing a cable station at the North Saddles (China), amounting altogether to £36,076. 2s. 1d., have been charged. One quarterly interim dividend of 1¼ per cent., amounting to £31,250, has been paid for the half year, and it is now proposed to distribute another of like amount, together with a bonus of 2s. per share payable on the 15th instant, making with the interim dividends and bonus paid for the first half year a total distribution of 7 per cent. for the year 1885. The balance of £39,468. 2s. 5d. has been carried to the general reserve fund, which now stands at £565,644. 6s. 1d. In pursuance of the conditions upon which the issue was made, 102 of the Company's 5 per cent. debentures of 1880 were drawn by lot on the 15th ultimo for payment at par on the 1st May next. The new cable steamer, "Recorder," referred to in the last report, has arrived at her station at Singapore, and the ss. "Agnes" has left for England to be overhauled for requisite repairs. The cost of the "Recorder," amounting with cable machinery and electrical apparatus to £42,606. 14s. 2d., has been deducted, as shown in the balance-sheet, from the Maintenance Ships' Reserve Fund. The cable between Victoria and Tasmania has been duplicated during the half year under review out of the Company's stock of spare cable at Singapore, and the cost (£31,190. 5s.) has been charged, as above stated, against revenue. The principal cable repairs during the half year have been on the Java-Australian and Penang-Singapore sections, but the communication has been uninterruptedly maintained by means of the duplicate lines. All the Company's cables are now in good working order. In consequence of the frequent interruptions of late years to the Penang-Singapore (original) cable resulting in a large annual expenditure for repairs, your Directors have determined to replace it with a new cable of brass-ribboned type, and a contract has been entered into with the Telegraph Construction and Maintenance Company for carrying out the work. It is anticipated that a large proportion of the old line will be picked up, and after it has been overhauled and re-served will be available for extensions or renewals in other directions. Your Directors regret to report that their efforts to induce the Indian Government to lower the transit rate for international messages across India have been unsuccessful. As, however, the Australian Colonies were, at Berlin, led to expect some reduction in the cable charges, the company, after consultation with the Agents-General, and notwithstanding the refusal of the Indian Government to participate in the reduction, have decided to reduce the tariff from the 1st July next by 1s. 4d. per word unconditionally, and to make a further substantial reduction provided the colonies agree to certain conditions proposed by the Company. It has also been decided to reduce the tariff between Europe and China from 8s. 4d. to 7s. 1d. per word, to take effect from the same date. The South Australian Government land line between Port Darwin and Adelaide has, as usual, been well maintained during the past half-year. In accordance with the Articles of Association, the Right Honourable Viscount Monck and Sir William McArthur, K.C.M.G., retire by rotation, and offer themselves for re-election. The retiring auditors, Mr. Henry Dever and Messrs. Quilter, Ball and Co., also offer themselves for re-election.

Indo-European Telegraph Company.

Directors' report for 1885, to be presented at the nineteenth ordinary general meeting of shareholders, to be held at the Cannon-street Hotel, on the 21st inst., at 12 o'clock:—

The Company's revenue from all sources for 1885 amounted to £116,150. 3s. 1d. as compared with £98,103. 11s. 9d., showing an increase of £18,046. 11s. 4d., or rather more than 18 per cent. The expenses were: On commercial and general account, £25,509; on maintenance account, £25,088. 8s. 11d., including £145. 5s 11d. paid to the Russian Government. Total, £51,597. 8s. 11d., as against £53,323. 19s. 6d., a decrease of £1,726. 10s. 7d. This is owing to the exceptional outlay on the duplicate Kertch cable which appeared in last year's accounts. The maintenance expenditure, however, includes the cost of alterations and improvements in the Company's lines. On commercial account there is an increase of £1,637. 7s. 7d., mainly occasioned by staff for additional through circuits and the expenses attendant upon the increased business done. Deducting the above expenses, taking credit for £4,578. 11s. 7d. balance brought over from 1884, and debiting income tax, there remains the sum of £67,456. 5s. 1d. From this amount £10,625 has already been paid for interim dividend, leaving a balance of £56,831. 5s. 1d. The Directors, after setting aside £15,000 to the reserve fund, propose the declaration of a dividend for the last six months of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 30s. per share, both free of income-tax, making in all 12 per cent. for the year, and carrying forward £1,456. 5s. 1d. to the credit of 1886. The extra cable circuit secured by the new agreement with the Post Office, and the other additions made out of revenue to the Company's system, aided by the second wire granted by the German Government, by which two special circuits are secured from London to Teheran, continue to prove of great advantage to the working of the Company's system. The above improvements have also contributed to enable the Company to deal satisfactorily with the additional business thrown upon the lines during the past year. The large augmentation of revenue is quite exceptional, and is owing to the total interruption of the Eastern Company's lines for some three weeks, the disturbances in Burmah and the Afghan frontier question, and it is satisfactory that the £18,046. 11s. 4d. of additional revenue has only occasioned an increased expenditure on commercial account of £1,637. 7s. 7d. At the Telegraph Conference of Berlin, in response to the desires expressed by the Indian Government and the German Postmaster-General, His Excellency, Dr. von Stephan, it was determined to reduce the rate to India from the 1st of July next from 4s. 7d. to 4s. per word. This will cause a diminution of the Company's revenue, but the Board were of opinion that the time had come for a material reduction in the tariff. Reductions were also arranged for, to Australia and China, the amounts of which are not yet fixed, to take effect from the same date. The following Directors retire by rotation, and offer themselves for re-election:—Col. James Holland and H. H. Meier, Esq. The auditors, Messrs. C. F. Kemp, Ford, and Co., public accountants, retire and offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies	Closing Prices. April 7.		Business Done Week Ending April 7. Highest.	Business Done Week Ending April 7. Lowest.
Anglo-American	36½,	37½	37½	35¾
Do. Preferred	60½,	61½	61⅞	59⅜
Do. Deferred	12½,	13¼	13⅜	12¼
Brazilian Submarine	11,	11¼	11 3-16	10⅞
Cuba	10½,	11	10½	—
Do. Preference	17½,	18½	18½	—
Direct Spanish	1½,	2	—	—
Do. Preference	10½	11	10¼	—
Direct United States Cable	10¼,	10½	10 7-16	10¼
Eastern Telegraph	12,	12¼	12¼	12 1-16
Do. 6 per Cent. Preference	14¼,	14½	14⅜	14 5-16
Do. 5 per Cent. Debentures, 1899	105,	108	107½	—
Eastern Extension	13⅛,	13⅜	13⅜	13⅛
German Union	9½,	10	—	—
Globe Telegraph and Trust	7,	7¼	7¼	7 1-16
Do. Preference	13½,	13¾	13⅝	13½
Great Northern	14½,	15	14⅞	14¾
Indo-European	38,	39	38¾	37¾
Reuter's	6½,	6¾	—	—
Submarine	200,	210	207	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	9½,	9¾	9⅜	9⅛
Western Brazilian	7⅜,	7⅝	7 9-16	7 7-16
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	100,	104	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	15-16,	1 1-16	—	—
Oriental	¼,	⅜	—	—
United Telephone	12½,	13	12 13-16	12 7-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	3⅛,	3⅜	3⅛	—
Do. (fully paid)	5,	5¼	5¼	5 1-16
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	1,	1¼	—	—
Maxim-Weston	5-16,	7-16	—	—

MISCELLANEOUS.

Telegraph Construction	36½.	37½	37	36⅞
India Rubber, Gutta Percha, and Telegraph Works	23	24	23¼	23

TRAFFIC RECEIPTS FOR MARCH, 1886.

Companies.	March, 1886.	March, 1885.	Increase.	Decrease.
Cuba Submarine	3,300	3,510	—	210
Direct Spanish Telegraph	1,751	1,467	284	—
Great Northern	20,000	—	—	—
West Coast of America	3,525	—	—	—

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NOTES.

AUSTRIA.—Experiments are to be carried out to connect Vienna and Pesth telephonically.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 9th inst. amounted to £2,862.

ESTIENNE'S TELEGRAPH.—It is stated that some satisfactory experiments have been made direct between Paris and Berlin with M. Estienne's apparatus.

TONKIN.—It is said that the first occupation of M. Paul Berl upon his arrival at Tonkin was to endeavour to develop and systematise telegraphic and telephonic communications.

WEST INDIES.—The cable between St. Vincent and St. Lucia, which we announced in our last week's issue as being interrupted, has been promptly repaired. That between Dominica and Guadeloupe, however, remains interrupted.

ROYAL INSTITUTION OF GREAT BRITAIN.—According to the arrangements for the Friday evening meetings after Easter, on Friday, May 28th, Prof. Oliver Lodge, D.Sc., will lecture on "Electrical Deposition of Dust and Smoke."

THE MINES COMMISSION.—After seven years' labour the final report of this commission has been issued. The value of electricity as an illuminant for mining purposes is briefly touched upon, and is considered in our leader in this issue.

AMERICA.—New York has 23,038 gas lamps, and 647 electric lights. Boston has 9,781 gas lamps, and 401 electric lights. Baltimore has 5,191 gas lamps, and 243 electric lights. These figures are given under the authority of the *Scientific American*.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 9th inst. were £2,369, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

FIREPROOF CABLE.—At the recent fire at the Liverpool Telephonic Exchange, we understand that two 100-wire fireproof cables, recently supplied by Messrs. Walter T. Glover and Co., Manchester, were exposed to the full fury of the flames, and stood the test thoroughly.

INSTITUTE OF CIVIL ENGINEERS.—On the 31st ult. there were on the books of the institution 20 honorary members, 1,542 members, 2,111 associate members, 501 associates, and 926 students—together 5,100, being a net effective increase of 313 during the preceding twelve months.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—At the meeting of the Board of Directors on April 14 Mr. Alfred Marshall, formerly partner in the firm of Messrs. F. Huth, Grüning and Co., of Valparaiso and Lima, was unanimously elected chairman of this company, in place of the late Mr. Robinson Kendal.

CARDIFF.—Forty arc lights, each of 2,000 candle-power, are shortly to be put up at the Barry Docks, Cardiff, so that the work of excavation and construction will be able to be continued day and night. Mr. Walker, the contractor, is fully convinced that he can by this means complete the dock by September, 1888.

THE EFFECT OF A SILENT DISCHARGE ON A SENSITISED PHOTOGRAPHIC PLATE.—Dr. Tommasi has recently brought before the French Academy of Science an account of experiments made to show that the silent discharge from an induction machine has upon a sensitised photographic plate the same effect as the ultra violet or chemical rays. The experiment must be performed in complete darkness.

NATIONAL SOCIETY OF INDUSTRIAL SCIENCES AND ARTS.—*L'Electricien* of April 10th says: We have just received the general programme of the first International Exhibition of this society, which will take place at the Palace of Industry from July to November. An entire group, the tenth, is devoted to electrical industries. For all information apply to the Management of the Society, 24, Rue Saint Marc, Paris.

EXHIBITION IN NEWCASTLE.—It has been definitely arranged to hold in Newcastle an International and Colonial Mining, Engineering, and Industrial Exhibition in 1887, in celebration of the Royal Jubilee. The exhibition, which is to be held in the grounds of Singleton House, Northumberland-street, will be divided into fourteen departments with subdivisions, thus guaranteeing a larger display of products.

CHEAPER TELEPHONY.—We notice that the Lancashire and Cheshire Telephonic Company are instituting a cheaper service. They are developing what may be termed a multiplex service, in which several subscribers use the same wire. The rates for this new service are, when used for commercial purposes, £15 per annum, reduced to £12 if a three years' contract is given. When used for domestic purposes, £10 per annum, or £8 per annum for three years' contract.

CLUBDOM.—The Junior Carlton Club has arranged to duplicate the electric light machinery, and to introduce a set of accumulators of a thousand ampere-hours' capacity. The extension of the lighting—as was the case with the original lighting—is in the hands of Messrs. B. Verity and Sons, who are also going to put 100 lights in the grand circle of the Alhambra Theatre, and are now about commencing work at Scarborough, where the installation will consist of 120 lights.

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY.—In pursuance of the conditions upon which the Five per Cent. Australian Government Subsidy Debentures were made, 251 debentures of £100 each were drawn by lot on the 12th April, at the offices of the company. The said debentures will be paid off at par on the 1st day of July next, at Messrs. Barclay, Bevan, and Co., 54, Lombard-street, E.C., after which date interest on them will cease. Full particulars will be found in our advertising columns.

WHAT IS A ROADWAY?—A new political periodical, *The State*, hazards the following bit of applied science in its first number. The italics are ours. "Electricity for driving tramcars and even underground railway trains at much less than the cost of horse, or steam, or air, or cable power—that is the latest thing we hear of in the way of science. The public will soon hear of the scheme in detail. The only novelty in it is that *no special roadway will be required, for electric cars are already running along the beach at Brighton and elsewhere.*"

BALLOONING.—Mr. Eric S. Bruce has been engaged lately in arranging a captive balloon for exhibition during the summer season at the Crystal Palace. The balloon will have a capacity of 80,000 cubic feet, and will carry several passengers at a time. It is proposed to have an ascent by day and night. At night time the electric light will be used by means of the apparatus devised by Mr. Bruce, and his system of flashing signals will be demonstrated. Several important improvements in the details of the signalling apparatus have been effected, the result of the experience obtained during the experiments carried out for the Government.

TELEPHONE CHARGES.—Mr. C. Lever, writing from Bowden to the *Manchester Guardian*, criticises somewhat severely the high charges made by the Lancashire and Cheshire Telephonic

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Exchange Company. It will be seen from another note that the company is taking some action in the matter. Mr. Lever's criticism, however, is more one of detail for the shareholders of the company to consider, as well as the subscribers, rather than a scientific one. He maintains that the company pays the parent company £2 per annum for each pair of instruments, which is an unnecessary payment and should be stopped, and the subscriptions decreased in proportion.

TELEPHONY IN FRANCE.—No one has a right in France to establish a telephone line intended for private use without having first obtained authorisation from the State, and by paying an annual tax. It is felt that while this is just, so far as the public lines are concerned, it falls very heavily upon men who connect their house with their factory or their sale room, as in that case the State is not prejudiced, nor is there any diminution of revenue. A petition has been sent to the Minister of Posts and Telegraphs on this subject, and a request made that he may find it possible to moderate, even if h does not abolish entirely, the tax hitherto imposed by the State.

ABERDEEN AND THE TELEPHONE.—The New Works Committee of the Harbour Board of the "granite" city have recently been considering the expediency of erecting telephone poles on the quays and reclaimed land. As the result of their deliberations, they have resolved to recommend to the Board that the Telephone Company should remove the poles at present placed along the quays on the south side of the docks; that in the event of the companies being unable to carry the wires over the private property along this route they should be allowed to place the poles along Commercial-road, and, among other conditions, that the company should be required to relieve the Board of all responsibility in connection with the erection of poles and wires.

ELECTRICITY IN THE KITCHEN.—Miss Harriet Lawrie, otherwise known as the "Electric Star," describes in a letter to the *Era* how she was able to light her kitchen fire from her bed room through the medium of electricity. Having made the necessary connections between the fireplace and her room, she says:—"In my bed room I placed a four-cell bichromate battery, with a lever attachment, to raise the elements from their cells. In order to light my fire I had only to raise the lever (which was placed within my reach), thus lowering the elements, completing the circuit. The platinum wire in the kitchen then became incandescent, setting fire to the lightning paper, which in turn set fire to the tissue, and this to the patent wood, &c., and it was a complete success."

THE SILVERTOWN COMPANY.—Several changes in this Company's Board of Directors took place at the last extraordinary general meeting through the death of the late chairman, Mr. Henderson. Mr. Robert Henderson, nephew of the late chairman, and son of the late Mr. Robert Henderson, who with Mr. S. W. Silver, was one of the founders of the Silvertown Company, has been appointed to a seat on the Board. This gentleman's position in the City of London makes him a valuable addition to the direction of the company. Mr. S. W. Silver has become chairman of the company, and Mr. Mathew Gray, the general manager, has joined the Board as Managing Director. The trusteeship for the debenture holders has devolved upon Mr. George Henderson, son of the late chairman.

GALVANOMETERS.—M. d'Arsonval presented to the French Physical Society, at the meeting of March 19th, a galvanometer with a movable circuit of great sensitiveness, which he has arranged for his physiological researches. The frame carrying the coil of the galvanometer is suspended in a field given by two parallel hard iron magnets, whose like poles are in the same direction. The lines of force are drawn in by a piece of soft iron placed at the centre of the four poles and of the suspended frame of the galvanometer. The inventor says the deviations are rigorously proportional to the intensity of the current in the coil. The intensity of the magnetic field may be varied by placing the two magnets farther apart or closer together. This galvanometer has the same dead-beat property as the inventor's former model.

PETROLEUM AS FUEL.—We have great pleasure in announcing that Messrs. Ransomes, Sims, and Jefferies, of Ipswich, supply their portable steam engines with an ingenious and simple apparatus which enables them to burn petroleum, and some of the engines so fitted have already been at work for a considerable time, burning only petroleum, with satisfactory results. Petroleum, as is well known, is procured in some countries, such as Russia, Brazil, &c., from natural springs or wells, and it is consequently obtainable there in its crude state at a very much lower cost than coal; it is therefore of the utmost importance that engines sent into these countries should be able to burn every description of fuel that may be indigenous, thereby utilising steam at its minimum cost. It is suggested that these engines will be largely used for electric light purposes in countries where petroleum is cheap and coal dear.

A MAGNETISED CORSET.—That ladies may have trouble with their watches, even if they take care not to bring them near a dynamo, is shown by the following story told by the *Electrical World*:—A young woman of Columbus, Ga., about to visit the station of the electric light company, was told to leave her watch at home lest it be magnetised by the strong electric current. She did so, but complained afterwards that her watch would not keep good time. She sent it to a jeweller, but he reported that it was not magnetised, and kept good time. Still, whenever she carried it, her time was too slow, although when she left it in her room it ran correctly. A gentleman who knew of the circumstance suggested to the young lady that she wear another pair of corsets when next she carried the watch. She did so, and had no further trouble with the watch. The steel springs in her corsets had been magnetised.

PROTECTING BUSINESS PREMISES.—We are glad to see that the American plan of utilising electricity for protective purposes—at any rate against burglars—is becoming more common. Not twelve months since the premises of Mr. Horton, in Sheffield, were broken into, and £100 worth of ivory stolen. After that robbery permission was obtained for an electric bell to be attached from the warehouse to the house of Mr. Whittaker, who resides on the adjoining premises. The electric bell was placed in one of Mr. Whittaker's bed rooms, and a few days ago the warehouse was again broken into just before 10 o'clock. Mr. Whittaker was quietly reading, when he suddenly heard the electric bell ringing in the bed room. Of course he knew that something unusual had occurred, and after giving a hasty glance round his own premises, to see that they were secure, he made with all speed to the Central Fire Station. He obtained the assistance of the police, and the burglars were captured.

COLONIAL AND INDIAN EXHIBITION.—A meeting of the reception committee was held on Monday at the Society of Arts. The committee considered a report from the sub-committee as to the arrangements which could be made for excursions for colonial and Indian visitors. Mr. Somers Vine, the official agent of the Exhibition, attended, and reported to

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the committee the arrangements which had been made with the railway companies with the view of affording extended facilities for railway travelling to all colonial and Indian visitors coming to the Exhibition. The chairman reported that in accordance with the wishes of the committee, and with the approval of H.R.H. the Prince of Wales, he had communicated with the mayors of some of the chief provincial cities asking if they would arrange for visits of parties of distinguished visitors. It was resolved that a subscription list should be opened; and the hope was expressed that those who have enjoyed the benefit of colonial hospitality will avail themselves of this opportunity of contributing to the entertainment of those who come to England from the colonies and from India for the purpose of visiting the Exhibition.

The Blackening of Incandescent Lamps.—Mr. Lucas, in a communication to the Academy of Sciences, suggests that some absorbent be introduced into the lamps to stop the dulness that gradually arises in them. He says:—"We know that in incandescent lamps there is produced in course of time a carbonaceous deposit upon the inner surface of the glass globe. This gradual decrease of transparence would be especially injurious for powerful incandescent foci. I have endeavoured to determine the true cause, and my experiments prove that it consists in the presence of molecules of oxygen within the lamp. We find, in fact, that the rate of increase of the deposit is in direct relation with the pressure of the internal gas We should arrive at an infinite slowness, or, in other words, at the cessation of the deposit, if we could obtain and preserve an absolute vacuum within the glass globe. A molecule of oxygen, not removed, combines with the carbon near its junction with the metallic conductor, a region in which the temperature cannot reach the melting point of the conductor. There is thus formed a molecule of carbonic oxide. This molecule, then, coming in contact with the incandescent portion, the temperature of which is high enough to produce dissociation, projects the carbon against the inner surface of the glass globe and leaves the oxygen at liberty to combine again."

Messrs. R. E. Crompton and Co.'s Works.—The students of the Institution of Civil Engineers, accompanied by Mr. Forest, the well-known secretary, visited Messrs. Crompton's electric light works at Chelmsford on Wednesday, the 7th inst. On their arrival at 1 p.m., after light refreshment, they commenced their inspection of the works in the heavy machinery department; here they had opportunities of examining the various parts of dynamos of all sizes, and also of armatures in all stages of construction. In this department, among the various large tools which were objects of considerable attention, was a circular saw used in cutting up 8in. square bars of cold wrought iron; a large new milling machine manufactured by Messrs. Kendall and Gent; also a large planing machine used for all heavy dynamo bed plates. The visitors next passed into the testing department, which was found to be well fitted with all the most modern appliances, including very large rheostats, a large number of measuring instruments, photometers, &c. Passing onwards, attention was drawn to a three-cylinder compound Willans engine, driving direct a large Crompton dynamo. This set was of the type exhibited at the International Inventions Exhibition, and was here used for doing all electrical work required in the works for shop lighting, both arc and incandescent lamps, and also for driving motors, working the fans in the smith's shop, and all the shafting in the pattern shop. Ascending to the first floor, or bobbin shop, the visitors were enabled to examine armatures of every size and description in various stages of completion, the sizes of these varying from an armature able to work 12 lamps at 2,000 revolutions to one capable of generating 100,000 watts at 400 revolutions. On this floor also projectors of all sizes, and hand lamps of English and other patterns were on show. The new pattern of high pressure steam valve, which the firm had just completed, was very favourably remarked upon. Proceeding to the next floor, instruments, switches, and minor fittings of every sort and description were to be seen in progress. Returning to the ground floor the visitors were shown through the erecting shop and stores, and thence to the pattern shop, foundries, painting, and smith's shops. In this latter a high-pressure steam hammer was seen, used for forging, shearing, and punching. In the new erecting shop was seen three complete combined plants each capable of giving 100,000 watts at about 400 revolutions, one of these being specially put under steam for the inspection of the visitors. Prominent among other features of interest which cannot be detailed at length were the fittings for a complete set of gear necessary for a light ship. These embraced dynamos, engines, boilers, glazed lantern, containing four arc lamps suspended on gimbals, &c. The whole works, which employ upwards of 400 men, show in every department the steady progress which this branch of engineering is now making.

Electric Light in Mills.—The Gülcher Electric Light and Power Company have recently erected for Messrs. Jonas Brook and Brothers, Meltham Mills, Yorkshire, one of the largest installations of incandescent lamps carried out in that county. The following is the arrangement of the lamps:—No. 1 large room, comprising black dressing, winding, and beaming department, 140 lamps, 20 c.-p.; No. 2 large room, comprising white dressing and beaming machines, 71 lamps, 20 c.-p.; dressing room, comprising colour dressing machines, 36 lamps, 20 c.-p.; starch boiling room, 4 lamps, 20 c.-p.; black stock room, 3 lamps, 20 c.-p.; slaying room, 4 lamps, 20 c.-p.; engineer's room, 1 lamp, 20 c.-p.; stoves, 1 lamp, 20 c.-p.; total number of lamps, 260. The 260 lamps in this installation are of Swan-Edison 90-volt type, and are driven from a No. 5 Gülcher compound-wound dynamo machine of their latest and most improved type. The machine is capable of giving a current of 220 amperes at 100 volts E.M.F., or an electrical output of 22,000 watts, at a speed of 500 revolutions per minute, so that it is large enough to enable the installation to be extended should Messrs. Brooks and Brothers desire additional light. The motive power for driving the dynamo is taken from the main shaft, which is fitted with a friction pulley. This avoids the inconvenience of fast and loose pulleys and striking gear, and answers the purpose admirably. The current from the dynamo is led by cables neatly cased into three main switches and cut-outs, each fitted in a box with lock and key. The current is then split into three circuits, one of 140, one of 84, and one of 36 lamps, and led to the different departments. The lamps are tapped off the mains in circuits of five. Each lamp is fitted with a switch and cut-out, enabling any portion of the installation to be switched on or off as occasion offers. The incandescent lamps themselves are all suspended from the ceiling by means of long wrought-iron pendants, and in order to obtain the utmost effect from the lamps, each is fitted with an opal reflector 6in. in diameter. This installation is the third of the Gülcher Company that Messrs. Brooks have adopted. The second installation has been supplied for lighting their Royd Edge Mill, where a No. 4 compound-wound dynamo is used to run six arc lamps in the dye-houses, and twenty incandescent lamps in the different departments. As this installation will ultimately be extended, the dynamo machine is capable of

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running 60 more incandescent lamps of 20 candle-power.' This installation shows the advantage of a system of electric lighting for factory work, which enables arc lamps to be used in dye-houses or large buildings, and incandescent lamps in the small rooms or departments, both being driven from one dynamo machine, and in fact from the same arrangement of circuits. The system has been adopted in other mills in Yorkshire, and the following may be mentioned as the most prominent firms who are using it:—Messrs. Jas. Watkinson and Sons, Holmfirth; J. Sykes and Co., Brockholes; and E. Fox and Son, Dewsbury.

Adoption of the Electric Light in Government Offices.—The factory of the Royal Army Clothing Depôt, Pimlico, has been fitted with a large electric light installation. This branch of that establishment consists of a large hall, 200 by 38 by 48ft., with side galleries three stories in height, besides two large ironing and pressing sheds, engine and boiler rooms, fitters' shops, machine and general store rooms, and clerks' offices. The hall is fitted up with sewing machines, driven by shafting from a steam engine, and sewing tables. The side galleries are occupied by cutters, viewers and inspectors of work completed, trimmers, finishers, &c. The total number of workpeople engaged in the hall alone is 1,600. The entire establishment was until lately lighted by gas, the total number of burners being 850, each consuming from six to eight feet of gas per hour, making the air very vitiated. The light was unsteady, and owing to the necessity of keeping it close to the workers, very injurious to their eyesight and general health. It was therefore proposed to substitute the electric light. In 1884 some interesting experiments were made to determine the best positions for the lamps and the candle-power that should be adopted. A small Schukert dynamo was hired, and 66 lamps of 10, 16, and 20 candle-power by Messrs. Woodhouse and Rawson, Swan, Edison, and Pilsen-Joel were fitted on standards at sewing machines and tables. By the use of counter shafting the engine-power of the factory engines was utilised. These experiments proved that 10 candle power lamps were most suitable. The installation was then proceeded with from designs of the R.E. Department of the Home District. The dynamo and switch-board were obtained by tender from the Anglo-American Brush Company, the former being one of their Victoria compound-wound slow speed type, giving 110 volts at the terminals. The engine is one of Messrs. Hornsby and Son's semi-fixed compound engine and boiler, of 25 nominal horse-power, with their new patent governor. No counter-shafting is used, the power being transmitted direct from the engine fly-wheel to the dynamo by one of Messrs. Cayley's 12in. leather belts, and the running is remarkable for its steadiness. The lamps are 10 candle-power, 52-volt Victoria, supplied by the Anglo-American Brush Company, arranged in parallel circuits, two in series. Owing to the probability of extensions, considerable margin has been allowed in the size of the cables, which were supplied by Messrs. Callender and Co. and W. T. Glover and Co. The lamp leads were supplied by Messrs. W. T. Glover and Co. and Latimer Clark and Co. The whole of the wiring, &c., was very well carried out by workmen hired from the Gülcher Electric Light Company, under the superintendence of Mr. E. Dawson, A.S.T.E., assistant surveyor. This company also provided all the standards, cut-outs, cable junctions, and fuses, and general small fittings. Total number of lamps, 1,070; total prime cost of the installation to the War Department, £2,100, including engine and fitting up engine room. Following that at the Tower of London, carried out in 1884, this is the second electric light installation made by that department.

The Electric Lighting Act Amendment Bills.—Mr. W. Livesey writes in the *Journal of Gas Lighting* with regard to the amendment in the Bills now before the House of Lords, that nearly all these provisions (amendments) are taken from the Gasworks Clauses Act, or special Acts relating to gas, and, so far as circumstances permit, are word for word the same. There is nothing in these provisions prejudicial to gas companies, or that would entitle the companies to be heard against them; notwithstanding, the Gas Companies' Association have given instructions for the proceedings to be watched, and permission to be heard applied for if it should be found desirable. In the same paper it is noted that the Manchester City Council Gas Committee will attend and give evidence, not for the purpose of placing any obstacles in the way of a full development of the electric light, but simply to safeguard the interests and property of the corporation. The Leeds Corporation have appointed a deputation to proceed to London with the town clerk, and support the Government measure. The Convention of the Royal and Parliamentary Burghs, held in Edinburgh, agreed to the motion that "The Convention memorialise Her Majesty's Government to introduce into their Bill in Parliament for the amendment of the Electric Lighting Act, 1882, a clause to provide for the protection of the interests of local authorities by requiring the undertakers, when such undertakers are not local authorities, to give security for the payment of all necessary costs incurred by local authorities in connection with applications for provisional orders, and to lodge such security prior to the serving of the notice provided for by Clause 4 of the said Act." The motion was agreed to. At the meeting of the Association of Municipal Corporations, held at the Westminster Palace Hotel last week, the Mayor of Salford, Mr. J. Farmer, in the chair, the three Electric Lighting Bills were considered, and the report of the Law Committee thereon read and adopted. Sir G. Morrison explained that at a joint meeting of the Parliamentary and Electric Lighting Committees of the Leeds Corporation, held on the previous day, it was determined to support the Government Bill. He moved a resolution to this effect; and the meeting determined that a clause should be added, asking the Government to make the consent of a Corporation a condition precedent to a provisional order being granted to a company. The resolution was seconded by the Town Clerk of Birmingham (Mr. E. O. Smith), and supported by several representatives of large bodies. Sir G. Morrison said during the discussion that had taken place an attempt had been made to attribute the failure of the electric lighting companies to the purchase clause of the Act of 1882. Several gentlemen of engineering eminence had told him that the real cause of the failure (apart from the reckless speculation which had taken place in electric lighting shares) had been the fact that electrical science itself had not yet advanced so far as to enable companies economically to supply large towns from a central station. The Borough Engineer of Leeds and himself had discussed the matter; and he thought it was not impossible that other modes of power (the essential factor in all electric lighting installations) which would facilitate the use of the electric light in large towns would be available, and practically render the functions of electric light companies worthless. The resolution was carried unanimously; and, on the motion of the Mayor of Huddersfield (Alderman Varley), it was unanimously resolved that the town clerks of Leeds, Nottingham, and Birmingham, and representatives from the Corporations of Liverpool, Manchester, Blackburn, and Sheffield, be requested to give evidence in support of the resolution of the Association before the House of Lords Committee appointed to consider the Bills.

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RING ARMATURES AND THEIR GENERAL PROPORTIONS.

BY GUY C. FRICKER.

In the following investigation into the best proportions for ring armatures, square cores will first be considered and afterwards those of the cylinder pattern with the view of making a comparative study of their respective merits.

It will be seen at once that all dimensions of either ring may be expressed in terms of $\sqrt{a}$, a being the area of cross section. Thus, referring to Fig. 1, we may write

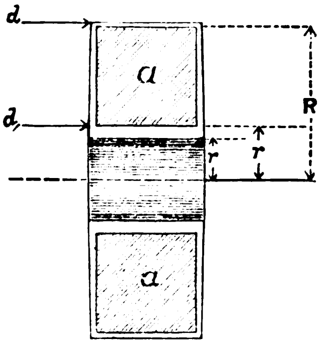

FIG. 1.

R = radius from centre to circumference $= (q+1)\sqrt{a}$,
r = „ „ inside of core $= q\sqrt{a}$,
r = „ „ „ winding $= x\sqrt{a}$,
d = depth of winding outside ring $= s\sqrt{a}$,
$d_{\prime}$ = „ „ inside „ $= (q-x)\sqrt{a}$;

also, $$\frac{\mathrm{R}}{r_{\prime}} = \frac{d_{\prime}}{d}$$

that is, $$\frac{q+1}{x} = \frac{q-x}{s},$$

whence $$x^2 - q\,x + s\,(q+1) = 0,$$

and $$x = \frac{q \pm \sqrt{q^2 - 4\,s\,(q+1)}}{2}.$$

The total E.M.F. generated in the coils of the ring may be expressed, as is well known, as follows:—

$$\mathrm{E} = \rho \,.\, \mathrm{M}\,a \,.\, \mathrm{N} \,.\, n \quad \ldots\ldots \quad (1)$$

Where M = magnetic density per unit of area in the core.
a = cross sectional area of armature core.
N = number of turns of wire round the ring.
n = number of revolutions per minute.
ρ = a "constant" converting into units of E.M.F.

Calling the number of layers on the outside of the ring l, the sectional area of the conductor (including insulation) α, and the width which each wire occupies on the circumference w, N may be expressed in the following manner:—

$$w = \frac{l\,\alpha}{d} = \frac{l\,\alpha}{s\sqrt{a}}$$

$$\mathrm{N} = \frac{l\,d_{\prime}}{d} \cdot \frac{2\,\pi\,r_{\prime}}{w} = \frac{l\,(q-x)}{s} \cdot \frac{2\,\pi\,x\,s\,a}{l\,\alpha} = \frac{2\,\pi}{\alpha} \,.\, x\,a\,(q-x).$$

Substituting this value in equation 1, and including all constants under ρ, we get

$$\mathrm{E} = \rho \,.\, \mathrm{M}\,x\,a^2\,n\,(q-x)$$

For purposes of comparison M may also be included under ρ, for whatever be the general proportions of the core the same magnetic density is assumed per unit of section. We can therefore write

$$\mathrm{E} = \rho\,x\,n\,a^2\,(q-x) \quad \ldots\ldots\ldots\ldots \quad (2)$$

Substituting for x and taking the + sign, we have

$$\mathrm{E} = \rho\,a^2\,n\left[\left\{\frac{q + \sqrt{q^2 - 4\,s\,(q+1)}}{2}\right\}\left\{\frac{q - \sqrt{q^2 - 4\,s\,(q+1)}}{2}\right\}\right]$$

$$= \rho\,a^2\,n\left[\frac{q^2 - \{q^2 - 4\,s\,(q+1)\}}{4}\right]$$

$$= \rho\,a^2\,n\,s\,(q+1) \quad \ldots\ldots\ldots\ldots \quad (3)$$

The negative sign in the value for x gives, in this case, an identical result for E.

The factor n in Equation 3 must vary of course with different diameters if a constant peripheral velocity is required; on the other hand, it may be necessary to keep the spindle speed constant, in which case

$$\mathrm{E} \propto a^2\,(q+1)$$

The first condition in comparing the proportions of similar types must be, of course, to keep the weight constant. Now the expression

$$\left(r + \frac{\sqrt{a}}{2}\right) a$$

evidently indicates a value proportional to the weight of the core, and this may also be written

$$a^{\frac{3}{2}}\,(q + \tfrac{1}{2});$$

thus when the weight is constant

$$a^{\frac{3}{2}} \propto \frac{1}{q + \frac{1}{2}}.$$

Now, when $a = m$, let

$$\frac{1}{q + \frac{1}{2}} = p,$$

then $$q = \frac{1}{p} - \tfrac{1}{2},$$

and $$q + 1 = \frac{1}{p} + \tfrac{1}{2},$$

and $$\mathrm{E} \propto m^2\left(\frac{1}{p} + \tfrac{1}{2}\right),$$

or $$\mathrm{E} = \rho\;m^2\left(\frac{1}{p} + \tfrac{1}{2}\right) \quad \ldots\ldots \quad (4)$$

Still including all constants under ρ. Now let

$$a = t\,m,$$

then $$\frac{1}{q + \frac{1}{2}} = t^{\frac{3}{2}}\,p,$$

and $$q + 1 = \frac{1}{t^{\frac{3}{2}}\,p} + \tfrac{1}{2},$$

and $$\mathrm{E} = \rho\,t^2\,m^2\left(\frac{1}{t^{\frac{3}{2}}\,p} + \tfrac{1}{2}\right) \quad \ldots\ldots \quad (5)$$

The results in 4 and 5 may be written,

$$\mathrm{E} = \rho\left(\frac{m^2}{p} + \frac{m^2}{2}\right),$$

and $$\mathrm{E} = \rho\left(\frac{m^2\,t^{\frac{3}{2}}}{p} + \frac{m^2\,t^2}{2}\right)$$

from which we see at o ice that E increases indefinitely with t.

Taking the other case of a constant peripheral velocity, the importance of making A large is still more marked, for

$$n = \frac{\mathrm{V}}{2\,\pi\,\mathrm{R}} = \frac{\mathrm{V}}{2\pi(q+1)\sqrt{a}}$$

V being the perpheral velocity.

Substituting this value for n in Equation 3 we have

$$\mathrm{E} = \rho \,.\, \frac{\mathrm{V}}{2\,\pi} \cdot \frac{a^{\frac{3}{2}}}{q+1} \cdot s\,(q+1)$$

$$= \rho \,.\, \frac{\mathrm{V}}{2\,\pi} \,.\, s\,a^{\frac{3}{2}}$$

And condensing constants as before

$$\mathrm{E} = \rho \,.\, a^{\frac{3}{2}} \quad \ldots\ldots \quad (6)$$

The above considerations show that cores should be constructed of great radial depth.

It is interesting to notice from Equation 6 that the effect of increasing the diameter of a core of any given area is simply to reduce the spindle speed at the expense of weight and efficiency, the extra winding on the armature doing nothing towards giving an increased output.

There is a way open, however, for increasing the output in such a ring, viz., by multiplying the number of poles in the "field." In some cases this may be considered a convenient method of developing the powers of a dynamo, but it is open

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to serious objections. To illustrate this, take the case of two rings of equal weight, the one being twice the diameter of the other, and let them rotate in "fields" of two and four poles respectively at equal peripheral velocities.

For the sake of convenience call the small ring A, and the larger one, revolving in the 4-pole field, B.

Supposing an equal depth of copper to be on the outside of each ring we have, say, $\frac{N}{2}$ coils in series on A (N coils altogether), cutting Ma lines of force twice per revolution, thus

$$E = \rho\, 2\, M a n \frac{N}{2} = \rho M a n N.$$

On B, the conductor will be one-half the sectional area of that on A, because there will be four groups parallel instead of two; thus there will be N coils in series (4 N altogether), cutting $M\frac{a}{2}$ lines four times per revolution; but as this large ring will make but half the revolutions of A, the E.M.F. will still stand

$$E = \rho M a n N.$$

The lengths of wire will be as $\sqrt{2}:4$ respectively, but that on A being twice the size of that on B, the weights will be as $1:\sqrt{2}$, showing a saving of nearly 42 per cent. of copper in favour of A.

Instead of taking an equal depth of copper on A and B, it would be more correct to consider this dimension as bearing a fixed proportion to $\sqrt{a}$ as has been done in the first calculations; for the whole system of magnetic resistance being considered as $\frac{\text{length}}{\text{area}}$ it follows that for purposes of comparison we ought rigidly to adhere to this inverse ratio.

The areas in A and B are as 2 : 1, therefore the depths of copper should be as $\sqrt{2}:1$. The effect of this would be to equalise the weights of copper and at the same time raise the output of A . 42 per cent.

Certainly, when considered in the abstract, multipolar machines do not appear to advantage, the more especially when it is remembered that a similar excess of copper will be apparent in the field magnet coils.

It may be remarked that the ratio of $1:\sqrt{2}$ is that existing between the lengths bounding any given area when contained in one or two similar rectangular or circular figures, and it is natural that in the same sense in which it is wrong to make multiple magnetic circuits *outside* the armature, it is also a mistake to do so *within* it.

The first of these errors has been pointed out by Kapp and others, but, strange to say, the second, although identical in character and involving the first, has not hitherto been understood.

In passing on to the cylinder type machine, we are met by some little difficulty in choosing a common stand point from which to view both forms in an impartial, and at the same time

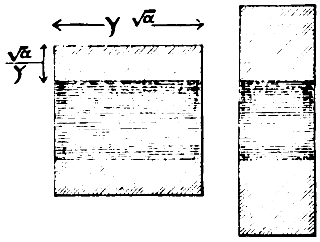

FIG. 2.

in a sufficiently accurate manner. It will, perhaps, be most convenient to consider the case in which the areas a in the two cores are identical; also the number of turns N, and the external depth of winding $s\sqrt{a}$; it will then follow that the inner annulus will also be the same size in each ring.

The length of wire in any case will evidently be

$$l = 2\,N\left(\gamma + \frac{1}{\gamma}\right)\sqrt{a},$$

where γ is the coefficient of $\sqrt{a}$ as shown in the diagram. The value for γ will gradually diminish as the core is shortened, becoming unity in a square core.

The surface speed of the square core will be greater than that of the cylinder for the same number of revolutions in the ratio, as

$$q + 1 : q + \frac{1}{\gamma};$$

but from the nature of its construction the square core would be able to run at a higher surface speed than the cylinder, chiefly on account of the spindle being shorter and there being so much less tendency for the wires on the periphery to swell out and become displaced. Practically speaking, for the case in point the spindle speeds may be equal for the same conditions of good working. The weight would be proportional to

$$\left(q + \frac{1}{2\gamma}\right)a^{\frac{3}{2}}$$

Thus the square core would be heavier by

$$a^{\frac{3}{2}}\frac{(\gamma - 1)}{2\gamma}.$$

A far more important point, however, is the relative polar surface in the two machines.

Taking m to represent the angular extent of the pole pieces in degrees, the surface on each side face of the square core would be

$$\text{Surface} = \frac{m\pi}{360}\left[\left\{\sqrt{a}\,(q+1)\right\}^2 - qd^2\right]$$

$$= \frac{m\pi}{360}\left(2\,q\sqrt{a} + a\right).$$

the top surface being

$$\frac{2\,m\pi}{360}\,(q+1)\,a.$$

Multiplying the surface for one side face by two, and adding all up, we have

$$\text{Total surface} = \frac{m\pi}{180}\left\{a\,(q+2) + 2\,q\sqrt{a}\right\} \quad . \; . \; (7)$$

In the cylinder there is only top surface to be considered, and this will be equal to

$$\frac{m\pi}{180}\left(q + \frac{1}{\gamma}\right)\gamma a \quad . \; . \; . \; . \; . \; . \; . \; (8)$$

The value for γ at which the expressions in 7 and 8 will be equal is

$$\gamma = 1 + \frac{a + 2\,q\sqrt{a}}{a\,q}.$$

The general tendency in cylinder machines is to make $\gamma = 2$ and $q = \cdot 5$ or thereabouts; thus it will be seen that the total polar surface comes very far short of what it would do in a square core of the same area. Taking the above values for q and γ, the comparison for the two cores in question would be as follows:—

Cylinder core.			Square core.
$5\,N\sqrt{a}$	= length of wire on armature	=	$4\,N\sqrt{a}$
n	= number of revolutions	=	n
$\frac{3}{4}\,a^{\frac{3}{2}}$	= weight of core	=	$a^{\frac{3}{2}}$
$\frac{m\pi}{180}\,.\,2\,a$	= polar surface	=	$\frac{m\pi}{180}\left(2\cdot 5\,a + \sqrt{a}\right)$

Taking $m = 120$ degrees

$$\frac{m\pi}{180} = 2\cdot 09;$$

thus we should get in cores of 25 square inches sectional area, 104·5 square inches polar surface on the cylinder, and 141 square inches on the square core.

The 35 per cent. in favour of the square core here shown is a very important point, because it means a greater magnetic density, and consequent greater output. Still there are, no doubt, other considerations concerning weight and size which may commend the cylinder pattern in the judgment of many engineers of large experience.

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PROF. HUGHES'S INAUGURAL ADDRESS.

The following is an abbreviation of certain "Critical Remarks on the last Discoveries of Prof. Hughes respecting the Self-Induction in Metal Conductors," by H. F. Weber, of Zurich, as given in the *Centralblatt für Elektrotechnik*, No. 8, 1886.

The author says: "Hitherto the self-induction constant of every non-magnetisable metallic conductor has been regarded as a quantity whose value depends entirely upon the form and geometrical dimensions of the conductors, and consequently as entirely independent of the material of the conductor. Only for magnetisable conductors did the theory of electro-dynamics hitherto allow the material of the conductor to have any influence on the induction-constant. A magnetisable conductor will be circularly magnetised by passing a current through it, and this magnetisation greatly increases the induction-constant of the conductor, just as the iron core increases the coefficient of self-induction of a coil to an enormous extent. Prof. Hughes has arrived at quite other results. He found that the constant of self-induction of every metallic conductor (carbon included) is dependent on the material nature of the conductor, and varies in an extraordinary degree with the metal." The author then goes on to give some results from Hughes's paper, and continues:—"The theory hitherto held of the kind of dependence of the induction-constant (coefficient of self-induction) on the form and dimensions of the conductor has for a long time been developed formally in a completely general manner. From this development it may be deduced that the induction-constant of a long, thin, straight, stretched wire, with a circular section, and of the same diameter throughout has the form

$$Q = 2l \left\{ \log \left(\frac{2l}{e} \right) - 0{\cdot}75 \right\}$$

where l denotes the length and e the radius of the wire. If the wire is magnetisable, and if its magnetic moment increases proportionally to the magnetising force, its induction-constant (coefficient of self-induction) has a somewhat different form; then it becomes

$$Q = 2l \left\{ \log \left(\frac{2l}{e} \right) - 0{\cdot}75 + \pi k \right\}$$

where k is the coefficient of magnetisation.

"In accordance with this the induction-constant of a fixed length of such wire decreases in a logarithmic manner as the thickness increases. Prof. Hughes has made very searching measurements on the dependence of the induction-constant of rectilinear stretched wires on their thickness. These measurements gave him the universal result that the induction-constant of such wires depends on the thickness of the wire in such a manner that this constant has the smallest value for the smallest thickness, that it increases with the thickness, reaches a maximum value, and then again decreases." The author then goes on to give results from Prof. Hughes's paper, and says that the important contradictions which thus arise between theory and experiment demand a critical inquiry to ascertain on which side the error lies. He says:—"The following lines are to demonstrate that the causes of this contradiction are founded on a faulty interpretation which Prof. Hughes applied to his measurements, and that these contradictions disappear as soon as the results of the measurements are indicated in an appropriate manner." The first thing to which he objects is the measurement by the sonometer. Prof. Hughes has considered the effect proportional to the angle through which the second coil was turned to produce silence in the telephone. Now the effect is far from being proportional to this angle when the coils are of nearly the same size or the angle large. For a small coil at the centre of a very much larger one the effect is proportional to the sine of the deflection, and only in this case and when the angle is very small may the effect be taken as proportional to the deflection.

"Again, the effect itself does not depend alone on the induction-constant of the wire. If we take the coils and the range of effect so that the angle of deflection is proportional to this effect, we obtain for Q_1, the self-induction constant of the wire under consideration.

$$Q_1 = P_1 v + \left\{ P_1 v \left(\frac{1}{w_4} + \frac{1}{w_3} + \frac{1}{w_2} + \frac{Q_2}{w_2} + \frac{2l_3}{w_3} \log \left(\frac{l_3}{l_4} \right) \right) \right\} w_1$$

where w_1 is the resistance in this wire, v the angle of deflection, Q_2, Q_3, &c., the self-induction constants of the other wires, w_2, w_3, &c., their resistances, and l_2, l_3, &c., their lengths. P_1 is the mutual potential of the two coils when the two are parallel and one much smaller than the other." The author says that the term involving w_1 will, in certain cases, be far greater than the term $P_1 v$, and it is proportional to the resistance of the wire whose induction constant is to be measured. The neglect of the second term accounts for the curious results arrived at by Prof. Hughes.

Again, in respect to Prof. Hughes's experiments with wires of different metals, but of the same form, the author says he has lately made experiments, after the manner of Prof. Hughes, on wires of the same length and thickness, but of different metals (non-magnetisable ones), and then calculated the induction constants from the mathematical formula, and he could detect no difference in those constants.

ELECTRICAL CONDITIONS OF THE HUMAN BODY.

The first of a series of three lectures on the electrical conditions of the human body was delivered by Dr. Wm. H. Stone, F.R C.P., in the Royal College of Physicians on Thursday, the 8th April. The Vice-President occupied the chair.

Dr. Stone: Mr. Vice-President, brother Fellows, and gentlemen—Before I commence this lecture I feel it incumbent upon me to thank the president and the fellows of this old and venerable society for allowing me the use of this library. I must also thank them for allowing me to issue more than the usual number of invitations to scientific friends who are not immediately connected with the medical profession. There are many who have materially helped me in this investigation, which has now lasted for five years, and to them I must also return my sincere acknowledgments, especially to Mr. Gregory, to the professors of Cooper's Hill, to Dr. Lodge, of Liverpool, to Mr. Lant Carpenter, the son of my old and respected teacher, Dr. Carpenter, and last but not least to Prof. Hughes, the distinguished discoverer of the microphone. Having thus delivered myself of my gratitude, allow me to begin by saying what these lectures are not going to be. They are not going to be lectures on the so-called medical electricity. Medical electricity is a term of ill omen; and, indeed, it is incorrect. Hitherto the application of electricity to the human body has not come up to the expectations which are reasonable in the case of so powerful a force. It is evidently in embryo—in a state of origin; and it has come into use in medicine in a somewhat oblique, and somewhat accidental manner. It is a good physiological stimulant, a good test of muscular irritability, and in this way it has been taken up, more in a physiological than in a physical light. Besides this, it has suffered grievously from misrepresentation. We see every day in the papers the statement that electricity is life. Now, this is most undoubtedly untrue. No doubt we shall some day be able to find a closer relation between electricity and life, but at present we are not justified in making this statement. What I am going to endeavour to do in the three brief hours allotted to me is to establish certain physical conditions with regard to the human body, and to apply them perhaps in a simpler manner—in a more natural fashion—than has been done by previous investigators, more from the inorganic, more from the physical than from the physiological side. Very early in the history of electricity physiologists seized upon it, and very properly—distinguished men like Du Bois Reymond—and used it as a means of causing irritation in nerve and muscle. The galvanoscropic frog, which is a very delicate test of a current, and the employment of the induction coil, have to a certain extent kept back the physical investigation of how a current acted. The galvanoscopic frog is too delicate a test. It is an unmeasureable test. It responds, without our being able to know, to very small excitements, and the induction coil is a very complicated electrical apparatus, the actual working of which has been hardly fathomed by physicists. We have lately been able to find an apparatus which will to a certain extent supersede the galvanoscopic frog, and we are beginning to get at the root of the action of the induction coil. What I have to say more about the induction coil I shall reserve for the third and last lecture—on induction currents generally. Now I will only show you how we can replace the galvanoscopic frog by a telephone, and so find out more than we know about the currents that pass from the induction coil. I have a Du Bois Reymond coil, and I have laid on an electrical wire along the room to a series of telephones, and when I put the battery on I shall be able to make the telephones respond, jump and jerk, as does the electroscopic frog [Experiment.] Now, if you take any of these telephones from the wall you will find that it is responding to the secondary current of the induction coil. If I now withdraw the secondary coil it gets softer and softer; but if you put it up to your ear it can be heard when the primary is a long way from the secondary. I shall revert to this in the third lecture; but I wish to show you that the telephone can be used with induced currents as a galvanoscopic frog. The first discoverer of this fact was Prof. Hughes, the discoverer of the microphone. Now, I propose to occupy myself in the short time at my disposal to-day with the resistance of the human body. The first investigation of this kind does not begin, alas! with me. It occurred to many of the early observers that the human body must place some obstacle in the course of an electrical current which is technically termed resistance. Volta worked himself at it. He did not fully work it out, and we have a number of early observations by distinguished electricians. Volta, Humboldt, Lenz, Bertholon in 1736, Gilbert in 1801, Pschlmnikoff, Feschenes in 1839, Edward Weber and Wm. Weber, his brother, at Gottingen in 1835. I have an account of them in a magnificent work of Du Bois Reymond, but time will not allow me to quote from it. The best work among the early writers is undoubtedly that of Du Bois Reymond on the resistance of the uninjured human body. But all those early investigations upon the electromotive state of the living uninjured human body turned out unsatisfactorily. Even Du Bois Reymond himself, good man as he was, seems to have given it up in despair. He says in this very treatise which I have translated: "In no part of this province do we meet with such unaccountable freaks of experiment. To prove the most insignificant fact often calls forth efforts out of all proportion, and whilst in other cases the discovered contrivances have lasted for a long series of experiments, we are now in the position that almost every single experiment demands preparations which, if not complicated, yet necessitate detailed preparations whereby those experiments are the

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most lengthy one can imagine." I will not read more of it, but he goes on to speak of the errors in them, and finishes up by saying that the error of all those early experiments is so great (he names Volta and Humboldt) on account of what I shall name presently—on account of polarisation that those investigations, made in part carefully, but without great searching, are deprived of value through the circumstance that the polarisation of the electrodes was not taken into consideration. There is another reason why these early investigations failed entirely, that is that both Weber and those who followed him seem to have taken it for granted that it was an indifferent matter whether you measure the resistance of the human body with the ordinary constant current or battery—of low tension ; or whether you take the high tension secondary induced and momentary current from an induction coil. I believe I may claim to myself the small merit—if merit it be—of having found that the resistance of the human body with the ordinary battery current and with the induction current is totally different. With an induction coil I shall be able to show you it is very often only half—seldom more than two-thirds—what it is with the ordinary battery current, and I fear that the induction current used by Edward Weber, and ever since by observers of this phenomenon, must be discarded as untrustworthy. There are so many cases to be met with that it cannot be taken as it stands. There is also a very good paper by the Count du Moncel, which is what I may call the first approximation to a real estimate of the resistance of the human body. It is, indeed, a wonderfully good paper on the conduction of moderately good conductors, of imperfect conductors, in which he says, towards the end :—"The conductibility of the human body, although acting very much like those we have spoken of, presents certain peculiarities." And then he describes his experiment. "I employed electrodes of platinum, which I tied pretty strongly on the internal wrist of the patient"—or rather the lady patient, for it was his wife, who is still alive. Then he gives a description of the experiment, which lasted an hour and a half. Only by an unfortunate error, without intending any harm, he decomposed his patient. He electrolysed her, and the poor old lady still bears the traces on her wrists of a tremendous ulceration which he produced by his experiment. Count du Moncel has gone to his rest, but she remains to this day with scarred wrists, so that the professor made a great error through this electrolysing, though he got an estimate approximating to the real resistance of the human body—that is to say, the body of his own wife. He said it was equal to about 350, and sank to 220 kilometres of telegraph line. In those days there was a unit used in Switzerland and France which was called the French unit, a kilometer of iron wire such as was used for the telegraph, and he used very small electrodes. This kilometre of iron telegraph wire was four millemetres in diameter, so it may be taken practically as 10 ohms. Therefore, his estimate of the resistance of the human body was, say, 3,500 to 2,000 ohms—a very wide margin, but the latter figure approximates to what it really is. He destroyed the epidermis and caused ulceration, and it is remarkable that he could not get much lower than that. Now, what is the reason of the difficulties that have existed? The moment I began to experiment I saw that there were two if not three. The first is the difficulty of making a good contact, and up to lately there never has been a proper contact made. The electrodes used by Count du Moncel were only 4½ centimetres by 3 centimetres—that is, 1¾ inch—by 1⅛in. English measurement, and the proof that they were not large enough, that the density through the current was great, was that they produced physical injury. The difficulty is, first of all, in making a good contact. The human body is somewhat like a condenser or cable, as I have said. It is a mass of conducting material contained in a highly insulating envelope. The skin is such a remarkably good insulator that it can be made to excite frictional electrical effects by the dry soles of the feet. For example, we heard lately a story of an electric boy who, simply sliding with his feet on a carpet, could produce sparks from his person. But any body may slide along a carpet in the same way and light the gas from the sparks produced. That was the secret of the story of the electric boy. Then, secondly, comes the fact that the human body rapidly electrolyses. The human body, I shall be able to show you in the second lecture, is a secondary battery of no inconsiderable power ; and when a current, even a small current, passes through it, electrical decomposition is set up, which is reproduced in an antagonistic current, and which modifies entirely the measure of the resistance. Besides that there is a third action, and that in the syllabus I sent round to the Fellows I name electro-chemical-capacity. In a paper I read before the the British Association I spoke of the human body as a condenser. So rapid is the progress of science now that I think I must modify that term. Prof. Hughes, whose brilliant researches are well known, furnishes me with a far better name for that third condition of the body which gave me so much trouble, by calling it *self*-induction. That, again, I must leave to a later lecture. Now as to the contact and the mode of investigation. It is obvious that any contact or resistance through the skin must as far as possible be eliminated. We do not want to know the resistance of the skin. The resistance of the skin can go up to any amount. It is given by the latest writer on electro-therapeutics, Dr. Rosenthal, as 8,000 to 20,000 ohms. What we want to know is the resistance of the tissues which underlie this insulating layer. Dr. Rosenthal has gone at great length into the different conditions of the skin, but the whole thing seems to be unnecessary. The physiological conductivity of the deeper tissues, not of the mere skin, is what we want to measure, and the plain statement is that the contact should be infinitely large, mathematically considered, compared to any current which may be sent through it. If this condition is complied with the resistance can be brought down to something very moderate indeed. I must employ, therefore (and I find I have been anticipated in this as in many other things by Du Bois Reymond), what fortunately succeeded with me, and what I lighted upon more by accident than otherwise, and that is salt and water. I tried, of course, other things ; but thinking of lead as an inert body, I used two large leaden poles, and those have answered. If the patient is confined to bed, I place a little salt water solution on his feet or hands, and I wind a bandage round the wrist. In this way I get a good contact. When I have my contact it is important, in the next place, if I am to measure the resistance, that I should take anatomical points so as to make sure that the same part, the same proportion of the patient is being traversed by the current in every case, and I have found two very convenient indeed. One is the prominence of the ulna at the wrist, which is marked in most people, and the other is the external malleolus of the ankle. The advantage of this is that when the patient is stripped you can raise the arm so [shown], and you can get a measurement of the human conductor, certainly within a-fourth of an inch. Therefore, these are the two points I commonly use for measuring. I have used in my experiments in most cases Wheatstone's bridge, but time will not allow me to go into a description of it. As regards batteries, I need not occupy any time ; any battery which is easily managed with a tolerably good electromotive force will do. I am in the habit of using a chromic acid battery, and these, when they are in good working order, may be said to have an electromotive force of two volts each. Their internal resistance is so small, compared with that of the human body, that you can neglect the internal resistance of the battery. I may say that I tried some other methods of producing contact, but they were more or less unsatisfactory. Besides, they hurt the students very much, and so I had to come back to the large leaden contacts. In addition to that I have to ask in what direction do we want to test the current ? There are four principal directions through which it is worth while passing the current. From hand to hand has been commonly used, but from foot to foot involves the largest quantity of tissue, and therefore is the most interesting. You may pass it through limited parts of the body, but, usually speaking, from foot to foot and hand to foot will give you a very good estimate of the resistance of the main tissues of the body. The lecturer then referred to the following results he obtained by experiment :—

		Conductor.		
	ft. in.	ft. in.	foot to foot.	foot to hand.
Mr. Todd	5 6	5 9¾	945	1,320
Mr. Shackel	6 3	7 0	930	1,027
Hungarian Giant..	7 6	8 7	930	1,032

He then said. Let me here remark that I find that it is in the legs principally that tall men differ from short men—not in the trunk or arms so much. I have had an opportunity of measuring a large number of persons of varying heights, and some of these—two or three of the most remarkable—I have put down in the diagram before you. My colleagues here will recognise in Mr. Todd an old clinical clerk of mine. You will see he is 5ft. 6in. in height. He measured 5ft. 9¾in. of human conductor. Mr. Shackel was also my clerk, and was quite a young giant. He was 6ft. 3in. in height, and he gave me 7ft. of human conductor. The Hungarian giant was an Austrian soldier, who was brought over to this country and was said to be 8ft. high, but after a careful measurement I found he was only about 7ft. 6in. when stripped of his externals, and from his external malleolus to the ulna he gave me 8ft. 7in. of human conductor. This is the largest case I have had the opportunity of measuring. Now as to the method of proceeding. The first method I have put down on the syllabus is momentary contacts. [Experiment.] I have, in circuit, a Wheatstone bridge of rather a particular form, and I have a commutating key so as to send the current in two opposite directions ; and I have a double contact key which I will put in contact with the battery, and afterwards through the galvanometer. In this way I thought I was lessening the effects of polarisation, and in that way these observations were taken, and they agree with one another very fairly indeed. This is a demonstrating galvanometer, and if I put on two compensating resistances the galvanometer shows it. [Experiment made showing the resistance to be 1,160 ohms.]

Now, the reason why I have recourse to these alternating currents is what I mentioned before as the second difficulty—that of polarisation, which causes the resistance to rise steadily. This polarisation is really chemical decomposition taking place inside the body, and it acts as an opposition—an opposing electromotive force. For a long time I was very much troubled in this way. I could not get any readings that would agree with one another. Indeed, Du Bois Reymond seems to have been embarrassed in a similar fashion, and ends without giving a figure showing the resistance of the human body. He says, in short, "I have not taken the trouble to ascertain the resistance of the human body." By this phrase I really think he means that he was not able to get any congruous readings. When I read my paper to the British Association, at Southport, my friend, Dr. Oliver Lodge, of Liverpool, whom I have already named, said, "Why not use Kohlrausch's principle of an induced current from an induction coil, and use the telephone as a galvanometer?" The method is extremely pretty and charming, and upon that method I spent a year's work. This instrument [showing it] is Kohlrausch's induction coil. It is a very neat little piece of mechanism, and here you can read from this scale [showing it] what the resistance of the body is ; but it came out entirely different in every case. The discrepancy was so enormous that it was obviously due to some error in the experiments, or some fault of the instrument. This is the method by which Weber tried to find it out. The results differed as much as from 1 to 2, or 1 to ½. I may now go on to speak of other methods which were suggested to me. Momentary contacts I have mentioned, alternating currents I have left for the third lecture, but I have still to speak of the second method of Sir Henry Mance, and with that I hope to solve the difficulty without recurring to alternating currents. Sir Henry Mance, as he now is, is superintendent of the Persian telegraph system, and on May 8th, 1884, he brought before the Society of Telegraph Engineers—of which I have the pleasure of being a member—a method of eliminating the effects of polarisation and earth currents from fault tests. It is a very technical

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thing; but it amounts to this that a cable which is not acting well and in which the insulator has failed, is liable to set up a counter-electromotive force similar to that which I have named and which I shall presently demonstrate as occurring in the body. The body very much resembles a faulty submarine cable, and it occurred to me that this method might succeed better than the one I had wasted so much time on. I found it answer extremely well, and I was very much assisted by Sir Henry Mance, who wrote me the following letter: "I shall be very pleased if my method is of any assistance to you. I made a few experiments myself in that direction, but had no leisure to continue the investigation. From hand to hand I found the resistance was 900 to 1,100 ohms. The observation of the resistance was higher in consequence of polarisation. But I always corrected the results by my formula. I did no more than test one or two individuals for a couple of days, so I have no *data* of any value." Now, what is Sir Henry Mance's method? I have it here on the diagrams, and I have the whole apparatus, and a very beautiful apparatus it is, set up before you. This, as made by Latimer Clark, is a peculiar form of Wheatstone's bridge, which he uses. It can be done with the ordinary Wheatstone bridge, and I have done it with it. It is very much better to do it automatically here, because it requires very quick changes in consequence of the inconstancy of the resistance. It amounts to this that instead of cutting the currents as short as possible to stop polarisation, you let polarisation do its worst, and then you alter the conditions of the problem. [Experiment.] Mance's method against polarisation, used originally on the Persian Gulf cable, is:—

Let $R = R$ of coil A $\quad R_2 = R$ of coil B

$R_1 = R$ with coil $R_1 \quad R_2 = R$ with coil R_2.

Then
$$X = \frac{(R_1 \,.\, P_2) - R_2 \,.\, R_1}{R_2 + R_2 - R_1 - R_1}$$

or
$$X = \frac{A - B}{C.}$$

This is a complicated looking formula, but it really is not very difficult, and it can be made much more simple. Now I will endeavour to take a test on this method. Here I have my proportional coils. These two proportional coils are united to a cross piece, so that I can switch off at one motion. [Experiment shown, giving the resistance of the man's body operated on as 1,170 ohms.] Sometimes resistance rises, sometimes it falls. It is very difficult to say beforehand which way the polarisation will set, but I find it generally rises. That enables me, then, to go back to my diagrams, and to speak about what the actual resistance of the human body is. There is a very good diagram there made independently of me, in which volts are given at one side and amperes are given at the other, and the electromotive force was steadily increased so as to show the effect of it. The first two experiments were made by Mr. Lant Carpenter, and his able assistant, Mr. Wilkinson, and I prefer to put them down, for the reason that they are made by other observers. The third was made by me on the same patient some time before, and you see the agreement is most satisfactory. What I want to draw your attention to is merely the resistance from foot to foot. It began with 1,194, and went up after four minutes from counter electromotive force to 1,230 ohms, and then four cells were put on, and they seemed to break down the resistance. The diagram was as follows:—

	E M F. Volts.	Resist. foot to foot. ohms.	Current amperes.
First experiment...	2	1st minute R=1944	...... ·0016
		4th ,, R=1230	
Second experiment	4	4th minute R=1155	.... ·0031
Third experiment.	8	1st minute R=1130	.... ·0069
		4th ,, R=1160	

I think that these three experiments, considering that they were taken by different observers and at different times, may be considered to be very congruous indeed. Then there comes what is one of the most interesting points in the whole matter—that this resistance of the body is infinitely less than has been before thought. The question has been asked me, "But does not the size of the patient make a difference?" If a patient be healthy and well nourished and his muscles in good condition, it does not. We get traces of a very distinct physiological law, which I have named in the syllabus, that as the length of the lever—the mechanical law, as is the length of the bony levers—so will be the bulk of the muscles that move them, and so it appears in those three men of very different statures. All these men were active vigorous men, and, oddly enough, the smallest man gives the largest resistance by a little. [Diagram omitted.] From foot to foot you will notice there is only 945 against 930, and the Hungarian giant, who had been a soldier in the Austrian army and trained to military exercise, gave exactly the same figure as Mr. Shackel, who, I believe, was equally athletic. A difference comes out from foot to hand, where the difference is rather more marked. You have to pass through a very narrow conductor. Therefore I test with a larger bulk of the lower extremities. You notice the resistances come out very nearly alike—only five ohms difference. This point is, from a physiological point of view, of some value and importance. I cannot say that this law is universal. I do not claim that. In disease, in extreme illness, or in extremely fat people, in affections of the tissues, of course considerable differences take place. But in ordinary health you may say that the height does not materially modify it.

Now I have the last few minutes that remain to me to draw my conclusions from the question of the resistance of the human body. We must not calculate, as lately we have been doing a great deal too much, upon the safety of currents merely from the insulating power of the epidermis which may be accidentally broken down by so trifling a matter as saturation with salt and water. And many of those sad accidents at the International Exhibition and elsewhere are undoubtedly due to the fact that for a moment the insulating power of the skin gets broken down, and a strong current passes. On these subjects, a gentleman who has written a very excellent book, Mr. Cunynghame, has some very good facts, and he has written me a letter. He has been taking the resistance of the human body, and although he finds between two hands immersed in acidulated water 2,000 ohms, he draws my attention very explicitly to the facts. He says:—"May I suggest that there is one aspect of the question which I hope you will see your way to treat—that is, the real limits of safety for dynamos as to the electromotive force and intermittency. The subject has never been adequately treated, and the Board of Trade are much at sea on the question, particularly with regard to the limits of safety." They at present put down 200 ohms as the outside limit to be allowed, but many dynamos go up to 800 ohms, and there can be no doubt that, as familiarity breeds contempt, there will be more unfortunate men who will put their two hands on the brushes of a dynamo and suffer sudden death. At present the accidents are more serious than we know of, because I am afraid there is a trade coalition to keep them concealed. As physicians it is our duty to expose this and to stand out against it. It is thought that it would injure the future of the electric light commercially if these accidents were to be admitted and explained away, and so they are hushed up by giving compensation and presents, &c. Besides that I have a word or two to say as to what is pretty certain to be found—the alteration of resistance in disease. I have had a case which shows that this inquiry is not unpractical. It has given me great trouble to discover it, and I cannot say I have settled the point to my own satisfaction whether the human body acts as a fluid conductor or a solid conductor. The Count du Moncel and Du Bois Reymond believed it to be a fluid conductor. I am doubtful of this. The heat observations I have been able to make go the other way, solids and fluids are altered oppositely by a difference of temperature. In a case of dropsy, when the body gets waterlogged there is an enormously reduced resistance. Then I find that degenerated tissues and tissues where muscular fibre has been replaced by common fibrous tissue become infinitely less resistent. Muscle is not so good a conductor, and these differences are such large quantities that I do not think the observation can be accidental or instrumental. I had six cases of hemiplegia tested, and in all those cases the hemiplegic side resisted less; the fibrous tissue was a better conductor than the side on which the muscle was sound. In one case the difference was 420 ohms, in another 350, in another 360, in another 120, in another 550, and in another 730, all in the same direction. These surely cannot be all wrong; there would be some evidence of its being an instrumental error. I think we may take it for granted that paralysed muscle conducts better than healthy muscle. I am able to say besides, that certain metallic impregnations do influence the conductivity of the body. I have had the opportunity of testing, in cases of mercurial impregnation, lead impregnation, copper impregnation, and I have been working hitherto unsuccessfully with silver impregnation. With the first three I have succeeded. The lead is not very marked. In one case of copper impregnation I found that the right hand with which the coppersmith works his hammer, and the right side of which was impregnated more with copper than the other, conducted considerably better than the left hand, which he did not use much in his trade. In that case I was able to complete the observations by examining the urine, and from that urine, as a proof that it was impregnated with copper, I extracted 3 milligrammes of copper, which was analysed and weighed afterwards. The point of temperature I am hardly prepared to speak with certainty upon; but I have recorded the actual figures in a very curious case of ulcerative endocarditis, where I was able to test, during the paroxysms of fever, the sinking and rising of resistance, until death finally took place, and I found that when the body was hot resistance instead of being less was greater. But it is very seldom that an opportunity arises where one can with humanity make such an observation as this, and I am waiting for another case where I can do it justifiably. Here I may leave off for to-day, and will deal with the rest of the subject in the next two lectures.

(*To be continued.*)

*** Pressure on our space compels us to leave over to our next issue the continuation of Prof. Forbes' lecture, letters from several correspondents, &c.

CRIMINAL CARELESSNESS.—An accident, causing the death of a workman, occurred recently at Philadelphia. From the report of the accident in our contemporary the *Electrical World*, it would seem to be the result of the most criminal carelessness, and it is a great pity that the person who played so idiotic a part and switched on the current cannot be punished for his gross negligence. The report says:—"Daniel Coyle was instantly killed while making an electric light wire connection in front of Joseph Bell's shoe store, at 1,116, North Second-street. The electric lamp had set fire to the awning, and Coyle, who was in charge of the dynamo room at the Northern Electric Light Company's works, was despatched to attend to the wire, which was out of order. The electric current was shut off on that circuit, and he was at work on the bulkhead of the show window, making the temporary connection, when some one shouted from the pavement that the current had been turned on again. Coyle remarked, 'If they had let it alone a minute longer I'd have been done,' and toppled over with a groan on the awning. Young Bell, who was near him at the time, caught hold of his limp body and attempted to raise him, but receiving a violent shock, desisted. The senior Bell and others on the sidewalk promptly raised a stepladder and lowered the body, which was taken to an adjoining drug store, but found to be lifeless."

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NOTICE.

"The Electrician" will next week be published on Thursday, instead of on Friday. Contributions and advertisements should, therefore, reach the office by Tuesday evening's post.

ELECTRICITY IN MINES.

The final Report of the Commission on Accidents in Mines, issued last Saturday, loses some of its interest by being so long delayed, and also, perhaps, to some extent, by its recommendations having been forestalled or foreshadowed in preceding reports. Nevertheless, the inquiry, which has extended, we believe, over a period of seven years or more, has resulted in the accumulation of a vast amount of evidence and information which will be of immense service in giving a wide publicity to the conditions of safety attending the working of mines, and in encouraging the adoption of precautions approved by an authority so high as that of the eminent scientists and practical men who were members of the Commission. No specific points for compulsory legislative enactments are put forward in this Report, but the basis for legislation is indicated in several places, should opportunity and occasion seem to justify it at some future time. But meanwhile we have no reason to doubt the cheerful willingness of the owners of mines to work them on the safest principles; and the utility of Parliamentary Commissions often lies quite as much in the suggestions they are able to make for voluntary adoption as in their proposals for more stringent legal regulations. This is peculiarly the case where an industry so varying in its conditions and circumstances as that of mining is concerned. Not only are there many different kinds of mines, but mines of the same kind have each their own distinct characteristics and consequent risks. To meet every one of these by general laws would be impracticable, and would probably, if attempted, do as much harm as good.

To investigate thoroughly the whole system of mining which prevails in this country, to call attention to defects in supervision, and to more especially trace out those obscure causes of accident which have hitherto eluded inquiry, are what a Commission like this was peculiarly well qualified to do; and it has certainly not disappointed our expectations. It is chiefly in relation to the last-named subject, however, that we have studied the Report with much interest. It will surprise many people that although mining accidents on a large scale are usually due to the ignition of explosive gases, the aggregate number of casualties from this cause is only 22 per cent. of the whole. The remainder are due to miscellaneous causes which appear to be inseparable from mining operations at great depths; but it is noticeable that 41 per cent. are caused by falling of material from the roofs and sides of the excavations, and are we venture to think, traceable to deficiency of light, or, more exactly, might be avoidable if the workings were more efficiently lighted. These figures happily show that great benefits have been already derived from improved ventilation and the employment of delicate gas indicators in recent years, and that risks from the incursion of firedamp are gradually diminishing. As regards the avoidance of accident by having a good light, the Commission makes the following observations:—"The advantages in point of convenience and efficiency which attend the employment of electric glow-lamps for illuminating the pit's bottom and roadways immediately adjacent to it have already been demonstrated at several collieries where this utilisation of the electric light has been combined with illumination at the surface by arc lights. In applying electric glow lamps to underground illumination, to the extent indicated, through the medium of conducting cables leading from the generators to the pit bottom, it is essential to safety, as well as to the permanent efficiency of the installation, that the cables should be placed in positions where they are thoroughly protected against possible accidental injury. It is also essential, in all mines where firedamp has been known to occur, that the glow lamps should be excluded from direct contact with the air of the mine in one or other of the ways indicated in this Report. Portable, self-contained electric lamps have been devised which will furnish for several successive hours a light considerably superior to that of the best safety lamps, and which at the expiration of eight hours and upwards will still give a light fully equal to that of a freshly-lighted Davy lamp." It is added that the progress recently made in the construction of portable electric lamps affords promise of a speedy utilisation of such lamps to an important extent in coal mines.

Of course these lamps do not afford any indication of the condition of the atmosphere, and their use must, in most cases, be supplemented by firedamp indicators and safety lamps. Our own belief is that in the improvement of these two last-named appliances, both of which have now nearly reached perfection, lies the miner's chief immunity from explosion, always provided that the efforts to maintain ventilation are in no way relaxed. For exploring, and similar purposes, the glow lamp is invaluable. We should be glad if the miner could and would work with it and a portable battery affixed to his person; but we do not expect it, at all events not at present. We think, rather, that a wider extension of the lighting of the workings by means of the glow lamps, adequately protected, would lessen the ordinary dangers of his position, increase the amount of work he is able to perform, and enable him to do it with greater ease and comfort. The defect of the lamp as a gas indicator constitutes its great merit as a light giver, being subject to none, or nearly none, of those risks which attend the use of even the best pattern of safety lamps. For it should be borne in mind that the presence of explosive gas is not of itself dangerous to life. The investigations of the Commission have, it is true, brought out the startling fact that a very small percentage, as little as two per cent., of fire-

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damp is an element of extreme danger in certain conditions. But such small proportions of firedamp can be more easily detected by gas indicators than by the ordinary but dangerous method of a lamp flame. Moreover, if the gas, even in these slight proportions, is travelling at a rapid rate and accompanied by coal dust, the presence of an oil lamp rather enhances the danger of the situation. Hence, on many grounds, the substitution of more permanent illumination by means of the electric glow lamp for the ordinary miner's lamp would greatly reduce the normal risks, and, moreover, would allow of working in atmospheres which are at present unworkable.

One of the chief dangers, however, attending mining operations is the presenee, already referred to, of coal dust in what are called dry mines. This coal dust, impregnated with a little marsh gas, forms a mixture as inflammable as gunpowder, and is, of course, in the highest degree dangerous when shot-holes are being exploded for blasting purposes. Should the charge, instead of bursting inwards, blow itself out of the shot-hole, a considerable body of flame is projected "as from the bore of a gun;" the dry coal dust is ignited, and the most serious consequences may ensue. "If," says the Report, "a blown out powder shot occurs in a locality where the atmosphere contains a small proportion of firedamp (even not above two parts in 100 of the air), the presence of dry, fine, and porous dust, even if it be only comparatively slightly inflammable, may give rise to the explosive propagation of flame to distant localities, where either accumulations of inflammable or explosive gas-mixture (as in goaves or old working places), or deposits of very inflammable dust, may take up the explosion and still further extend its disastrous effects."

To the proper construction and management of these shot-holes a good deal of attention has therefore been given by the Commission; and one of their recommendations is that electricity should be preferred for exploding the charge. The firing of the ordinary miner's fuze is a dangerous operation of itself, and may give out a flame sufficient to ignite the surrounding atmosphere. Their use is condemned in this Report, and the use of electricity advised in the following terms:—

"Electrical exploding appliances present very important advantages from the point of view of safety over any kind of fuze which has to be ignited by the application of flame to its exposed extremity, as the firing of shots by their means is not only accomplished out of contact with air, but is also under most complete control up to the moment of firing. Their simplicity and certainty of action have been much increased of late years, while their cost has been greatly reduced, and but little instruction is now needed to insure their efficient employment by persons of average intelligence. For the foregoing reasons the use of electrical arrangements for firing shots in mines, where the employment of powder for blasting is inadmissible, should be encouraged as much as possible."

THE IRISH DEBATE AND THE CENTRAL TELEGRAPH OFFICE.

Probably at no period of the world's history has there been in a given time so great a dissemination of news as has been the case during the discussion of Mr. GLADSTONE'S Bill on Home Rule. The actual facts impress those who understand the nature of the work far more, we should imagine, than those who are altogether ignorant of the first principles of telegraphic communication. It will be unnecessary, therefore, to do more than tell our readers the facts of the case. On Thursday, the 8th of April, it may be stated that the number of words signalled from London was 1,500,000, the greatest number signalled on any previous occasion being 860,000. It will be seen from these figures that very little more pressure was required to have doubled the record. The apparatus used in dealing with large quantities of news is the Wheatstone automatic, and no less than 100 Wheatstone perforators were brought into operation on this occasion. Of these 30 were of the kind which punch six slips simultaneously, 13 were of the kind which punch three slips simultaneously, 31 were of the kind which punch two slips simultaneously, and 26 were single slip perforators. The amount of writing performed by the reporters may be estimated when we mention that the number of sheets of "flimsy" dealt with in the Central Telegraph Office on this single evening was about 15,000.

The figures so far are impressive enough, but they give merely the words signalled from London. In many cases one wire from London serves several offices, so that the same message which is signalled from London is read by each of these offices simultaneously. For example, there are wires from London which work simultaneously to Birmingham, Manchester, and Liverpool. A thousand words transmitted, therefore, upon this line are equivalent to three thousand words received—that is, a thousand each at the places named. The work on the subsequent evenings of the debate, though not so great as on this special occasion, was extremely heavy. The total number of words signalled from London on the evening of the 9th inst. was about 600,000. The number signalled on the 12th was about 504,000, and the number signalled on the 13th inst. was about 500,000. As we have said previously, the figures speak for themselves, and no credit which may be given to the Post Office officials is more than they deserve in carrying such work through without a moment's delay. We doubt if there is any other office in the world that would have been equal to such a demand.

CORRESPONDENCE.

PROF. HUGHES' RECENT EXPERIMENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On the 28th January of this year, Prof. D. E. Hughes, as the newly-elected President of the Society of Telegraph-Engineers and Electricians, read as his inaugural address a paper entitled "The Self-Induction of an Electric Current in Relation to the Nature and Form of its Conductor."

I regret that I was unable to be present at the reading of the paper, or on any of the evenings that were devoted to the discussion of the same; but, if I understand Prof. Hughes's meaning, the object of his paper is to prove that conductors of different metals and of different forms vary in their resistance in accordance with the nature of the electrical conditions under which they are placed. For instance, the resistance of a conductor would be different for a permanent current to what it would be for intermittent currents, the amount of the difference depending on the form of the conductor, *i.e.*, whether solid wire, strand, or ribbon, or a combination of two or more such conductors.

The apparatus for his experiments consisted of a specially constructed induction bridge in which the galvanometer was replaced by a telephone, and it was found to be impossible, however accurately the wires were balanced for a constant current, to silence the telephone when intermittent currents were passing in the battery circuit. If the galvanometer be used, a perfect balance is obtained, both with constant and intermittent currents. In Prof. Hughes's arrangement the sound of the telephone can only be reduced to a minimum; consequently, to produce silence he sends through the circuit counter currents produced by electro-dynamic induction, and

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then again alters the length of the wire in circuit until no sound is heard in the telephone, and the true resistance of the wire is supposed to be thus ascertained.

The counter currents are set up by two bobbins of wire, a primary and a secondary one, the primary being in the battery circuit and the secondary in the telephone circuit, so that, by altering the relative position of the two bobbins, variations in the currents of the telephone circuit can be produced.

Now, some very remarkable results appear to have been obtained with this novel combination of an ordinary Wheatstone bridge and the professor's "induction balance," and from these results Prof. Hughes lays down the following startling propositions for the guidance of the practical telegraph engineer and electrician :—

"A solid rod of iron is the worst possible form for a lightning conductor."

"The conductor, if of copper, should be of ribbon form, or, if of iron, of numerous stranded wires, or a wide ribbon of similar conductivity to that of the copper."

"That there is a remarkable difference in the resistance of a wire during the 'stable' and the 'variable' period, or, in other words, with the results obtained with a constant current or intermittent currents."

"An iron wire has with rapid currents *more than three times* the resistance during its actual work than that supposed to be its true resistance."

"The more rapid the contacts of a telegraphic instrument the greater will be the difference between copper and iron."

"A solid iron wire is unsuitable for telegraph instruments requiring extremely rapid currents."

"Copper would reign supreme if it were not for the fact that stranded iron wires have greater rapidity of action than copper."

Now these propositions which I have quoted are so opposed to all my experience that I at once put them to a simple but, I think, efficient practical test.

A circuit was made up of an astatic mirror reflecting galvanometer, a battery of one Grove cell, a rapid interrupter, and a strand copper conductor of about 250 yards in length insulated by suspension in the atmosphere.

The intermitter was so constructed that from one hundred to two thousand interruptions of the current could be made per minute.

The internal resistance of the battery was ·2 of an ohm, and the resistance of the galvanometer ·1, whilst the resistance of the conductor was 1·07 ohm, so that the total resistance of the circuit was 1·37 ohm. Under these conditions the deflection of the galvanometer was obtained, both with a constant current and with rapidly intermittent currents. The wire under test was then removed, and conductors of different metals and forms substituted for it, each conductor having identically the same resistance—viz., 1·07 ohm, as measured by Wheatstone's bridge, and it was found that, whatever the nature and form of the conductor, the deflection obtained on the galvanometer was the same, showing that the resistance of a conductor of constant section and material is directly proportional to the length and inversely proportional to the area of its cross section, or in, other words, inversely proportional to the weight per unit length, and that whether it is carrying a constant current or intermittent currents. It therefore follows that, having ascertained by well known laws the resistance necessary to carry a desired current, it matters not electrically of what metal or form the conductor is made. Of course I am referring to aerial wires for telegraphic purposes or for lightning conductors. For the conductors of submarine telegraph cables, of course these remarks would not apply, but that has nothing to do with the present case. Having satisfied myself in the matter I took no further notice of it, thinking that the erroneous impressions Prof. Hughes had conceived were of such a nature that he would soon discover his mistake, and immediately take means to rectify the same. But, now that I find the subject is likely to be re-discussed, I think it well to publish the results of my experiments, which prove, to my mind, that Prof. Hughes has been misled in endeavouring to obtain reliable results by a combination of electro-dynamic, electro-dynamic-inductive, and electro-magnetic-inductive currents, without a due regard to the laws which govern the same.—Yours, &c.

April 12, 1886. WILLOUGHBY SMITH.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The "Writer of the Article," whose letter you print on page 435 of your last issue, does me the honour of entering upon fresh issues, and, before the points that I have raised are settled, challenges me to discuss with him whether or not the general argument which he put forward on page 391 in your issue of March 26, demolishes Profs. Ayrton and Perry's theory of the constant-current motor, as set forth on pp. 453-454 of my treatise.

Your readers will perhaps not be surprised at my declining for the present to favour the writer with my opinion on the matter. I shall be happy to do so as soon as the points already at issue have been settled—not before.

And I take this course for two reasons. *Firstly*, that I am not going to allow the writer of the article to draw off on another scent until the actual point at issue is settled. *Secondly*, because the point still at issue, and which is the second of those raised by me in my letter of March 5 (p. 331), is a question of correct or incorrect definition; and it would be absurd to discuss any problems involving definitions until the definitions themselves are settled.

The two points originally raised by me (p. 331) were :—

(1) That the writer of the article was wrong in using the number 736 instead of 746.

(2) That the writer of the article was using the term "critical speed" in an incorrect sense—in a sense different from that in which it is used throughout my treatise, and, before me, by others whose authority in this matter has never been questioned.

The writer of the notice has since admitted that he was wrong on the first point. I was under the impression, from his letter of March 26, p. 391, that he had virtually given in on the second point, because he there says :—"Even accepting his (*i.e.* my) latest definition, I cannot help thinking that the term 'critical speed' is ill chosen. I should prefer to call it the proper working speed, *for it is that speed at which the machine will do what is claimed for it by the term self-regulation.*" The italics are mine. I italicise the words because if that is what the writer of the article means by his term "the proper working speed," it is—and he ought, if he had really read the book he was reviewing, to know it—precisely the same thing as that which I and others before me have consistently and persistently called "the critical speed." I have no authority to speak for M. Marcel Deprez, or for Prof. Ayrton, or for Prof. Perry, or for the others who have used this term for the past four years; but I should be surprised if they consent to change their definition at the bidding of a critic whom the courtesies of journalism leave anonymous, and who thinks it "ill-chosen."

When, therefore, in his review this writer went out of his way to declare that "a motor has no critical speed," alleging as the reason that it is not self-exciting, I wrote to you to point out that the writer was using the term "critical speed" in a different and incorrect sense. I thought I had made it quite plain in my letters that the term "critical speed" has nothing to do with the limiting speed of self-excitement, but refers to the speed at which the machine is self-regulating; and I thought further that, when the writer of the article so far relaxed as to say on p. 391 that he preferred to give the name "proper working speed" to that which everybody before had called the "critical speed" (though he thinks it ill-chosen), there was some chance of our agreeing as to facts, while possibly preferring our own names for the facts.

But the writer's last letter rudely dispels any such hopes, for he now turns round and says (p. 435) :—"To prevent any possibility of misunderstanding, I again repeat that no motor and no dynamo which is not wholly self-exciting can have a critical speed." Indeed! It is a magnificent assertion; but, unfortunately, it is not correct, unless he means by "critical

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speed" something very different from the meaning usually attributed to that term. What does the term critical speed refer to? It can only refer to one of two things:—

(*a*) The speed at which the dynamo or motor will do what is claimed for it by the term self-regulation.

(*b*) The speed below which the purely self-exciting dynamo refuses to excite itself.

If "critical speed" means (*a*) then I am right.

If "critical speed" means (*b*) then the writer who makes the above positive assertion is right.

It is simply and solely a question as to which is the definition. Does the term "critical speed" refer to the least speed of self-excitation or to the speed of self-regulation? That is the only question now open between us. I distinctly decline to enter upon any other topic until it is settled which of these two is the accepted definition amongst electricians, and I would request you, Mr. Editor, kindly to umpire this question as to what the fact is.—Yours, &c., SILVANUS P. THOMPSON.

Finsbury Technical College,
April 12, 1886.

THE ELECTRIC LIGHT AT LLOYD'S.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit us to thank Mr. Bernard Drake for his correction. No other information was before us than the paragraph referred to, which, of course erroneously, speaks of "the introduction of storage cells" as subsequent to, and consequent upon, the complaint of noise. The statement that the belts run "perfectly silently" shows that we were right in questioning the use of the words "driven direct," and this was the sole object of our letter.—Yours, &c.,

WILLANS AND ROBINSON.

Ferry Works, Thames Ditton, Surrey,
12th April, 1886.

PRIMARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am endeavouring to elucidate the present condition of electric lighting by means of primary batteries. For this purpose I am collating information concerning them with a view to publishing the result in connection with a book I am engaged on.

At present the subject is clearly in the realms of the unknown, and I should be very glad if those of your readers who are able to furnish any reliable data would kindly communicate with me as under. The testimony of manufacturers as to the excellences of their batteries is not solicited. I am already acquainted with the value of their superlative hyperboles.

The information I am anxious to obtain is—

Have any primary batteries been successfully employed for two years—if so, where, and for how many lamps?

The same questions as applied to one year's working, or even again for, say, eight months?

What is the largest number of lamps now worked from a primary battery, and for how long has it been in operation?

Again, can any places be named in England where primary batteries have been working over, say, eight ten candle-power lamps successfully for six or eight months?

By successfully I do not mean economically. We have not come to that yet. The question of cost is in this case only of secondary importance, and I am first desirous of locating any instances of primary batteries giving a *steady constant current nightly* for any period over six months.

I do not wish to exclude "damaging" information, as this is also of importance; and although I fear voluminous accounts could be written on this head, I should be glad to hear of any personal experiences of your readers.

It is only by inquiries such as the above that really reliable facts can be tabulated, and, therefore, such information will be of value, and highly esteemed by—Yours, &c.,

JNO. B. VERITY.

Moorcroft, Weybridge, April 10, 1886.

REDUCTION IN CABLE TARIFFS.

The Eastern Telegraph Company notifies that on July 1st the following reductions of tariff will take effect, viz.:—

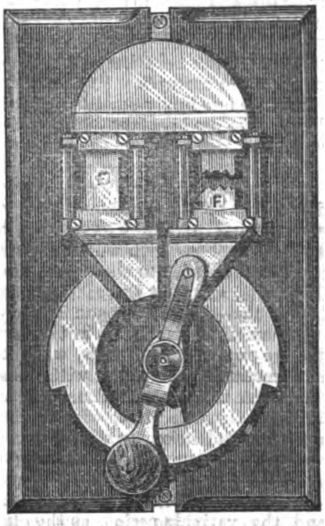
		s.	d.		s.	d.	
To India	From	4	7	to	4	0	per word
,, Hong Kong, Amoy, Foochow, and Shanghai	,,	8	4	,,	7	1	,,
,, Other places in China	,,	10	0	,,	8	9	,,
,, Macao	,,	8	9	,,	7	6	,,
,, Manila	,,	10	0	,,	9	0	,,
,, Cochin China	,,	7	9	,,	5	8	,,
,, *South Australia	,,	10	8	,,	9	4	,,
,, Spain	,,	0	6	,,	0	4½	,,
,, Portugal and Gibraltar	,,	0	6½	,,	0	5½	,,
,, Malta	,,	0	8	,,	0	7	,,

* The rates to other colonies in Australasia are not yet fixed.

Negotiations are in progress which, it is hoped, will be concluded in time to allow of reduced rates for Press messages exchanged with Egypt, India, and Australia to come into force on the same date.

BAILY AND GRUNDY'S CUT-OUT.

The illustration of this instrument almost explains itself. This design has been made to remedy a defect in the older forms, so that when necessary no delay may arise from the fusing of any foil. It will be seen that the arrangement is for



Baily and Grundy's Cut-Out.

two foils to be placed in the instrument, and if one is accidentally fused, all that has to be done is to take the switch, bring the other into circuit, and the whole thing goes as before. The spoilt foil can be replaced when convenient.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

Pressure on our space compels us to hold over the Report of the Discussion on Mr. BERNSTEIN'S Paper on "Low Resistance Glow Lamps," which took place on Thursday, the 7th inst.

PROF. HUGHES ON SELF-INDUCTION OF AN ELECTRICAL CONDUCTOR.

The following is an advanced proof, with which we have been favoured, of the remarks Prof. HUGHES would have made in reference to the discussion of this paper, but which he has preferred to put in writing:—

We have had a long and most interesting discussion, and I desire to express my warmest thanks to Lord Rayleigh, Mr. F. L. Pope, Prof. Forbes, Dr. Hopkinson, Mr. W. H. Preece, Dr. Fleming, Mr. FitzGerald, Prof. Silvanus Thompson, and Prof. Ayrton, for their most kind appreciation of my researches. They have all recognised the enormous influence which self-induction exerts, and the necessity of studying the phenomenon in all its effects. There have been some points raised which are important, but to which I must reply as briefly as possible, as I am anxious to bring forward the results of some further researches, which of themselves will answer many of the questions asked.

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Lord Rayleigh, while fully recognising the importance of the subject of my researches, seems not to have seized all the details of the method which I have employed, or the meaning of some of the terms which I have used. Prof. Forbes has already replied to that portion of his remarks; but in his communication dated February 24 Lord Rayleigh assumes that "the disturbance depends upon the rapidity of vibration, so that, in the case of of ordinary mixed sounds, silence can be attained only approximately." Prof. Silvanus Thompson has also asked me if the results depend on the rapidity of the contacts. In reply, I must state that in point of fact the rapidity of the contacts has no influence on the result, providing they are not more rapid than the rise and fall of the extra currents. Let us suppose that, instead of rapid contacts, we make and break the contact once only per minute, then, on making or breaking the contact, we shall hear a single blow or tap on the telephone; and if the communications of the bridge and telephone are arranged for the *stable* period, this sound will not be heard when the resistance of the bridge is perfectly adjusted. Suppose that we now change the communications so as to observe the *variable* period, still making and breaking contact but once per minute, we shall then find (if there is self-induction taking place in the wire under observation) that we have no longer silence at the previous adjustment of the bridge; if this disturbance is due only to the extra currents, we can reduce it to zero by throwing in from the sonometer an opposite momentary secondary current of *equal* value; but if the disturbance is due only to the resistance being changed, then we shall have to move the slide on the bridge until we have again perfect silence. In many cases we have to deal only with the extra currents, in others there is a far greater change in the resistance of the wire than in the force of the extra currents. Both can be adjusted separately or alone, but no change of the resistance slide will compensate for the induced currents, nor will any change of the sonometer affect in the slightest degree the required adjustment of the resistance slide; it is the first portion of the current that we are measuring by means of the telephone, or its action at the moment of making or breaking contact.

The object of my researches was to observe what takes place at the first instant of contact. To this the telephone responds with admirable precision, whereas, as I have already said, a galvanometer would be useless for such delicate experiments as I have made, where it is necessary that the self-induction of a few inches of straight wire may be readily perceived and accurately measured. The rate of speed of contacts, therefore, can be increased up to the point where the duration of the contacts is at least as long as the duration of the extra currents. In short wires the duration in time of the extra currents is exceedingly small, and much less than any duration of contact that I have used; a large electro-magnet would require a lengthened contact and a different method. The only advantage, therefore, of short contacts is the constant repetition of sounds or beats, enabling us the more readily and rapidly to find the required balance. All of the important points mentioned in my paper have been verified by independent methods, and they have also been repeated with slow and rapid contacts, as well as with widely different external resistance in the battery circuit; but I wish to show that the induction bridge gives perfectly reliable results, and that its readings can never be changed or misunderstood. I have chosen a fine German silver wire for the resistance bridge, because German silver has (even in the form of large wires) an extremely low inductive capacity; and this, when the wire is fine, is again reduced to a mere fraction as compared with what it would be in wires of 1 millimetre diameter of different metals. To test the instrument, place a piece of similar-sized German silver wire in the arm A B; we do not then find any trace of self-induction, as all the four arms of the bridge are equal; we may vary its resistance by shortening the length of the wire, but the bridge can only then be adjusted to zero by moving the resistance slide. Under these conditions there is no difference perceived between the stable and the variable period, as the changes produced are equal on all sides. Let us now replace this German silver wire between A and B by a copper wire of the same resistance, we then find that the stable period gives exactly the same zero as previously, but that a disturbance takes place in the *variable* period, and that this cannot be adjusted by the *resistance* slide, but that it is completely reduced to zero by the opposed induction current of the sonometer. Again, if we heat this same wire, its resistance is changed, and can only be compensated by moving the resistance slide; if we make this wire into a loop or a parallel return, there is no change in the resistance, but the *self-induction is reduced* at once, as shown by the sonometer; winding this wire in a coil increases the induction, and, within certain limits, we may perceive no change in its resistance, whilst its *self-induction has increased* several hundred per cent. Now, suppose we increase the resistance by heating and the induction by coiling the wire, we have then two distinct effects of known values, and the measurements given by the resistance slide and by the sonometer are precisely those which would have been given by either when measuring them separately; and this again proves that where we have a case of change of resistance it can only be met by adjusting the resistance slide, and where we are measuring the electromotive force of the extra-currents they can only be compensated for by the use of the sonometer. The cause of the extra or momentary increased resistance of a wire during the variable period can be explained. The current, on entering the wire, produces an extra-current of an opposite name, and that this really opposes the passage of the current is proved by the upsetting of the previously balanced bridge; there is, in fact, in this moment less resistance on the opposite side, and the balance can only be restored by the resistance slide.

There are, however, cases where this effect is entirely reversed, in which there is less resistance in the variable than in the stable period; this occurs when we are testing extremely fine wires with powerful currents, for the steady current heats the wire, thus introducing an extra resistance, which does not take place to the same degree with short contacts as in the variable period; but, as I have already said, care must of course be taken to avoid all such sources of error; and if we understand the subject, and know exactly where to look for errors, there should be no difficulty in constructing a bridge perfectly free from experimental error. The instrument and method which I have employed have a great advantage over any previously used, as from the exquisite sensibility of the former we are enabled, not only to verify all the results obtained by previous observers from their experiments on coils, but to do that which no other instrument or method has previously enabled us to accomplish, viz., to observe the self-induction of straight wires and the laws of its reactions (as in the contiguous portion of the same current in straight wires and sheets) entirely separate and distinct from the mutual reactions of one part of a coil upon another. These I have shown to be quite different, as an iron coil has less self-induction than a copper one, whilst in straight wires the reverse is the case. We must not neglect this all-important point, for in no way do my researches contradict well-known results, they simply go further, and show the physical reasons for certain phenomena; and where theory has failed to predict, or previous experiments to show, this has been due simply to the fact that no instrument existed sensitive enough to record or measure the effects which take place in the self-induction of a comparatively short wire free from external reaction.

Self-induction in coils has been a subject which I had of necessity to study in relation to my printing telegraph instrument. The movement of my armature being extremely rapid produced extra currents of sufficient force to trouble other instruments on the same line. I finally vanquished this difficulty in 1860 by an arrangement whereby the armature in rising instantly short-circuits its own electro-magnet, and by mechanical means (peculiar to the instrument) is entirely separated from the line, placing the line at the same time direct to earth or battery, but leaving the electro-magnet open, so that the return of the armature produces no extra currents that can affect the magnet or line. This has answered perfectly, and has been in use on all of my instruments since 1860 up to the present day. I have also used, since 1851, divided coils, whereby the current is passed through both coils in parallel, and not in series; this I use on lines less than 500 miles, not simply because of the diminished resistance, but because I found from experiments much less disturbing influence from the extra currents. I have, however, lately, by the aid of the induction bridge, been not only enabled to measure this difference, but to trace it to its true cause, and the following table gives a representative result obtained from numerous coils of different sizes and resistances, and with or without iron cores:—

Coils formed of 3 metres Silk-covered Copper Wire, 1 mm. in diameter, each Coil being 5 centimetres diameter.	Comparative Force of the Extra Currents.
One coil alone	100
Two similar coils in series	174
Two similar coils in parallel, but separated 5 cm. from each other	55
Same two coils in parallel, but superposed	81
One single coil of thicker wire of exactly the same form, length, and resistance as the two coils in parallel	75

The table shows an increase of force when two coils are in series, but not quite double, as a portion is reduced by the increased or added resistance. This is a well-known effect; but an interesting result is shown where the two coils are parallel and separated, giving then 32 per cent. less induction than the same coils superposed, and also 25 per cent. less than that of a single coil of precisely the same resistance. We can easily explain this, and trace the effect to the reactions of contiguous coils on each other. I have shown a remarkable difference in the inductive capacity of different metals when formed into wires of the same diameter; and as the order follows that of their respective specific resistances, it became an interesting study to know what would be the result if all the wires were of the same length and resistance. It is necessary to employ the same length, as the induction increases with the length; consequently a copper wire, compared with a brass wire of equal resistance, and therefore of greater length, would show a great difference in their inductive capacities. There are, however, several methods, free from experimental errors, which I have employed in this investigation. If we take wires of different non-magnetic metals of the same length and diameter, and reduce them to the same resistance by an added resistance comparatively free from induction, such as carbon, I find that there is apparently no difference whatever in the inductive capacity of the different metals, all (yet tried) giving by this method very nearly the same result; but in this case we have added an external resistance, and thus prevented any difference of action due to the different density of the current in metals of high and low resistance. If, instead of an added external resistance, we take wires of the same length and resistance, but of different diameters, we then find a marked difference in their inductive capacities; for instance, a pure copper wire, compared with a brass wire of double the diameter, shows a marked higher force in the copper wire. We might naturally believe that the brass wire, from its larger diameter, would give higher results than the smaller copper wire; but if we have thoroughly seized the importance of the phenomenon which I have demonstrated of the reaction of contiguous portions of the current on each other, we can easily prove that the larger the diameter of the wire the less will be its proportionate reactions, so that, whilst the resistance decreases directly as the increase in section, the reactions of the currents upon each other become *less* as the diameter increases, the resistance diminishing as a straight line, whilst the induction would follow a curve similar to that shown in the diagram.

The following table shows the electromotive force of the extra currents

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on wires and strips 1 metre in length, a chemically pure copper wire of 1mm. diameter being taken as the standard of 100, to which all the rest were compared :—

Wires of the same diameter, but of different resistance—1 metre in length.		*Wires* of the same resistance, but of different diameters—1 metre in length.	
Soft Swedish iron............	500	Soft Swedish iron............	400
Copper	100	Copper	100
Brass	65	Brass	88
Lead	50	Lead	81

Strips of the same width and thickness, but of different resistance—1 metre in length.		*Strips* of the same resistance and thickness, but of different widths—1 metre in length.		
12 mm. wide, $\frac{1}{10}$ mm. thick.		$\frac{1}{10}$ mm. thick.		
Copper	60	12 mm. wide	Copper ...	60
Brass	48	42 ,, ,,	Brass......	45
Iron...............................	45	72 ,, ,,	Iron	39
Lead	35	96 ,, ,,	Lead	29

In the above table, wires of the same diameter follow in the order of their resistance, iron alone being the exception; the same order is preserved in wires of the same resistance but of different diameters. In the latter case there is a nearer approach to equality, but they still show a difference of from 12 to 19 per cent., and whilst the non-magnetic metals have increased their inductive capacity with increased diameter, iron has fallen 20 per cent.; consequently, wires of different metals of the same resistance have not the same inductive capacity, owing, I believe, to the action of contiguous portions of the current, as I have already shown. If we reduce the extra currents by employing thin sheets or strips, there is in the case of iron a still more remarkable difference, for in strips of different metals of the same width the force of the extra currents in iron is actually less than that of brass, and if we compare an iron strip with an iron or copper wire of the same resistance, we have iron wire 500, copper wire 100, and the iron strip 45, or actually 55 per cent. less than the copper wire. In the case of wires a nearer approach to equality in inductive capacity is shown when they are of the same resistance, but in strips this is reversed, for here, when equality in resistance is produced by wider strips, the difference becomes greater, iron then having actually less inductive capacity than a lead wire of the same resistance. This extraordinary result must be due, not only to the reactions of contiguous portions of the current being less in sheets or strips than in wires, but also from an imperfect formation of the circular magnetism which takes place in all iron wires on the passage of an electric current. This, however, is only a partial cause, as we can obtain a still further reduction of the extra-currents by employing numerous fine wires separated from each other, the circular magnetism in the latter case being perfectly formed in each wire; but we still have the maximum experimental reduction due to the separated portions of the current no longer acting on each other. Copper and all metals show a similar reduction when we separate the wires of a strand conveying a current, but when the numerous wires are brought close together, copper approaches in value that of a solid wire, whilst iron wires are but comparatively little influenced by their closer proximity. I have tried all forms of conductors, such as square, stellar, tubular, &c.; they all show a gradual diminution of inductive capacity as compared with those of a solid circular section; in a solid conductor the maximum effect being obtained in the circular section, and the minimum in that of a wide flat sheet. We can reduce the self-induction of any metal far below the comparative force that I have given by widening the strip, or, still better, by diminishing its thickness as we widen it, and it is evident that if we keep the same width and gradually increase its thickness, we then approach the conditions of a solid wire; consequently, where it is necessary that we should be able to utilise a given amount of copper in the best possible form, so as to convey a current of an enormously high tension but of short duration, as required in a lightning rod, we should widen the conductor as much as the mechanical stability and durability of the conductor will allow, and I believe that a lightning conductor of copper 1 mm. thick by 10 cm. wide would satisfy the mechanical requirements whilst preserving the physical conditions necessary for a perfect conductor.

My experiments have shown clearly that a solid iron rod is unsuitable for a lightning conductor; but we may use a stranded iron wire or a flat iron sheet of the same conductivity as the copper. The iron wires should be galvanised, as all iron wires coated with a non-magnetic metal show a marked reduction in their inductive capacity; and here, as well as in the ribbon form of copper conductors, practice has guided our inventors in the right path, for it is an almost universal practice to galvanise iron wires in order to preserve them, and ribbon copper lightning conductors have been gradually replacing the most objectionable iron rod, for which there can be no defence based on experimental or scientific reasoning. I have already given the results of a compound wire of copper and iron made by myself, but I have since (through the kindness of Mr. W. H. Preece) been furnished with some most admirable specimens of American compound wires, the copper being electro-deposited upon a core of steel wire, and also some specimens in which the core is of copper with a steel exterior. I have thus been enabled not only to verify my previous results, but to prove that an exterior coating of copper has a most powerful influence in reducing the self-induction of its steel or iron core, for, if we take a given length of this wire and compare it with a similar length and diameter of copper wire, and taking for comparison the copper as a standard of 100, we have only 107, or 7 per cent increase for the compound wire, but if we file off the copper so as to leave the steel core bare, the inductive value of this same wire rises to 350. In order to study this effect, let us place an iron wire in the interior of a closely fitting copper tube, and insulated from it. This has no effect upon the iron wire; but if we join the exterior copper tube to the interior iron wire at both ends, the current passes through both at the same time, and the inductive capacity of this compound system is reduced almost to that of solid copper, as previously observed in the compound wires. These effects can be fully explained when we reflect that the circular magnetism produced by the passage of an electric current through an iron wire is produced only upon the exterior portion of the wire, and cannot take place when this exterior is, as in a compound wire, of copper, consequently a steel or an iron wire coated with copper of sufficient thickness is entirely free from this magnetic reaction. Now, if an exterior coating of copper has such an effect in reducing the self-induction of its iron core, it follows that an opposite effect should be produced by coating a copper wire with iron. Experiments with this, and also with a copper wire inserted in a closely fitting iron gas tube, prove that the effect was as foreseen, viz., a remarkable increase in the inductive capacity of the wire.

One result, however, which I did not foresee, although it is clearly indicated in the experiments quoted in my paper, is that not only is the inductive capacity of the interior copper wire increased to a great degree, but that a copper wire coated with iron has a higher degree of self-induction than a solid iron wire; in fact, its inductive capacity is not only higher than is possible to obtain from the softest iron wire, but its *resistance in the variable period* is proportionately greater than any yet remarked in a solid iron wire. I have made numerous experiments on this subject, and they all show that whilst copper in a straight wire or a single *wide* loop has a far less inductive capacity than iron, it has, on the other hand, the property of being far more excited by the reaction of iron, so that a straight copper wire can be excited by this reaction to a degree greatly exceeding that of a straight iron wire under precisely the same conditions. I will cite a few experiments which illustrate this point. A copper and an iron wire of equal resistance, and 1 metre in length, were measured for their inductive capacity and resistance, the inductive capacity of the copper wire being as 100, as compared with 400 for the iron. The resistance of the copper in the variable period had only 8 per cent. increase, compared with 128 per cent. for the iron; but a great change took place when each of these was placed in the interior of an iron gas tube of sufficient diameter to allow of the wire being insulated. The force of the extra-currents in the copper wire then increased 350 per cent., whilst the iron increased but 8 per cent.; the force of the extra-currents being now for copper 450, against 433 for the iron. The influence of an exterior iron tube on the resistance of the wire during the *variable* period was still more marked. The copper wire, which without the exterior iron tube had only 8 per cent. increase, now showed 934 per cent. increase, or, by direct measurement, 1 metre of this wire, during the rapid rise and fall of the current as in the variable period, had precisely the same resistance as 10·34 metres in the stable period, or a much greater difference than I have obtained from an iron wire; for the iron wire insulated in the gas tube only showed an increase due to this tube of 22 per cent., giving a total of 178 per cent. difference, or by direct measurement, 1 metre of the iron wire with its insulated iron sheath, in the variable period, required 2·78 metres to balance it in the stable period; thus copper shows more than three times the sensibility to an exterior sheath of iron than an iron wire itself. Iron appears to be self-contained, and, as regards self-induction, comparatively less acted on by an exterior influence. This is well shown in the case of coils, where the induction of a coil of insulated iron wire is but slightly increased by its own reactions, or those produced by the introduction of an iron core, as in an electro-magnet, whilst copper coils with an iron core show a remarkable increase. We can thus easily obtain extra currents of ten times the electromotive force of those from an iron coil of the same length, resistance, or diameter; and the resistance of a copper coil, which in the stable period may be far less than that of an iron coil, can, by means of its increased self-induction from the reaction of its iron core, be greater than that of an iron wire coil. At first glance this may be considered unfavourable for copper; but we must remember that whilst copper, in the presence of iron, can be excited to a far higher degree than iron, and consequently has stronger extra currents and greater proportional increased resistance in the variable period, this is really a measure of the work it is capable of doing, for we are able by means of this property to obtain the high efficiency of transformation of energy as in the secondary currents. In point of fact, a dynamo machine having its electromagnet and armature wound with insulated iron wire would, irrespective of its resistance, have an extremely low efficiency as compared with those wound with copper; and as regards the resistance of either of these wires, there can be no doubt that the resistance of the armature of a dynamo, or, in fact, of any coil of wire as measured during the stable period, gives no approximate indication of what its *real* resistance is during the period in which it is doing work.

Table A, on next column, shows the influence of an iron tube surrounding a straight iron or copper wire, compared with compound wires.

The table shows that the iron tube has a much greater effect upon the copper wire than on the iron wire, the effect in both cases being at its maximum when the tube is insulated from its central conducting wire, for when the wire is in contact with its tube there is evidently a shunt action, or species of eddy current, formed between the outer coating and the central portion. This I have been enabled to measure by interposing the telephone between the inner core and the sheath, or, still better, by employing a double insulated sheath of iron or copper, and joining

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them together at one extremity, the opposite ends being joined through the telephone; by this means we are enabled to measure the differential effects of the secondary currents generated in an inner and in an outer sheath. The table also shows the effect of joining the outer sheath at both extremities, thus allowing a true eddy current to form; this at once reduces the electromotive force of the extra-currents, but has but little effect on the differential resistance in the variable period. If, however, we place the wire in contact throughout, so that the effect from the centre to the exterior of each portion can at once be partially neutralised, then there is a marked decrease in its resistance; and if, as in a compound wire, the exterior coating is in direct and still more intimate contact with the inner core, we then have the maximum reduction. We can thus prove that the shunt effect, or partial neutralisation of the extra currents, takes place locally, and probably transversely. We see also, by its effect on the reduction of the resistance during the variable period, that the passage of an electrical current then takes place with less opposing resistance from the self-induction than could be the case if there were no internal partial neutralisation of the extra currents. No doubt this effect also occurs in sheets and strips, and has its influence in causing the remarkable reduction of self-induction that I have already shown.

TABLE A.

Wires and Iron Tube each 1 metre in length.	Comparative E.M.F. of Extra Currents.	Approx. comparative Increased Res. during Variable period.*
Copper wire, 2 mm. diameter alone ...	100	1·08
Same wire insulated in the interior of the iron tube	450	10·34
Same joined to the tube at both ends ...	275	10·00
Same in contact with the tube throughout its length	200	7·83
Compound wire (copper interior with steel exterior)	325	4·35
Soft Swedish iron, 2 mm. diameter, alone	400	2·28
Same wire insulated in the interior of the iron tube........................	433	2·78
Same joined to the tube at both ends ...	240	2·70
Same in contact with the tube throughout its length	215	2·60
Compound wire (steel interior, copper exterior)	107	1·20

* That of the Stable Period being taken as 1.

In conclusion, I once more desire to express my thanks to all who have taken part in the most interesting discussion that has followed the reading of my paper. Mr. W. H. Preece and Prof. Forbes, who have seen my experiments, have borne testimony to the truth and care with which I have carried out these researches; and our well-known American electrician, Mr. Frank L. Pope, has cited examples showing that the superiority of a stranded iron wire was noticed even in the early days of telegraphy, and that the superiority of a compound wire over an ordinary iron wire is a well-known practical fact in the United States. He has also cited a case similar to the experiments of Prof. Guillemin and myself, where an electro-magnet was destroyed by lightning, notwithstanding that the telegraph line was joined direct to earth in advance of the electro-magnet. I am glad that many of the results of my researches are fully borne out by the practical experience of the past; and I hope that those which have as yet not been foreseen in theory or applied in practice will receive the same attention and verification that all discoveries should undergo, as I feel convinced that their truth will become more and more evident when repeated in the laboratory or applied in practice.

PARLIAMENTARY INTELLIGENCE.

HOUSE OF LORDS, APRIL 12.

ELECTRIC LIGHTING ACT (1882) AMENDMENT (NOS. 1, 2, AND 3) BILLS.

Lord MONSON moved that the following lords be named of the Select Committee :—Earl Cowper, the Earl of Camperdown, Viscount Bury, Lord Balfour of Burleigh, Lord Rayleigh, the Earl of Crawford and Balcarres, Lord Methuen, Lord Houghton, and Lord Lingen.

The motion was agreed to.

On the motion of the Earl of WEMYSS, Lord Bramwell and, on the motion of Lord HOUGHTON, Lord Wolverton were added to the Committee.

Some discussion arose, on the motion of Lord GRIMTHORPE, to entitle all petitions against these Bills, presented before the 15th inst., to be referred to the Select Committee; and to declare that the petitioners should have leave to be heard before the Committee; but it was decided to leave the discretion in this latter respect to the Committee itself.

PETITION AGAINST THE ELECTRIC LIGHTING ACT (1882) AMENDMENT (No. 3) BILL.

The following petition has been presented against this Bill and in favour of No. 1 Bill:—

To the Right Honourable the Lords Spiritual and Temporal in Parliament assembled. The most humble petition of the Electric Lighting Act Committee, sheweth as follows :—

1. Your petitioners were formed as a general committee on the suggestion of the Right Hon. Joseph Chamberlain, when President of the Board of Trade, to frame clauses in amendment of the Electric Lighting Act, 1882, and to confer with the Board of Trade as to the terms of provisional orders and licenses, and your petitioners claim to represent the commercial and scientific interests of the United Kingdom on the subject of electric lighting.

2. A Bill is now pending in your Right Honourable House under the above name or short title, whereby it is proposed to amend Section 27 of the Electric Lighting Act, 1882, by enacting that the expression "prescribed period" in that section, used in relation to the purchase of any undertaking or part thereof, shall mean such period not exceeding 42 years from the date of the passing of the Act confirming the provisional order or of the special Act authorising such undertaking as may be specified in that behalf in such provisional order or special Act; provided that where no period is so specified, the prescribed period shall be deemed to be a period of 30 years, and that no period exceeding 30 years shall be so specified in relation to the purchase of any undertaking or part thereof, except with the consent of the local authority within whose jurisdiction such undertaking or part thereof will be.

3. The practical effect of the said amendment will be to slightly extend the period after the expiration of which local authorities are, under the powers of the Electric Lighting Act, 1882, empowered to exercise an option of purchasing electric lighting undertakings within their district.

4. The effect of the said purchase option section in the Act of 1882, has been to deter capitalists from embarking their money on electric lighting undertakings, and virtually to stifle the development of the electric lighting industry in the United Kingdom, and your petitioners submit that any such option of purchase as is given to local authorities by the Act of 1882 cannot but have the effect of preventing the development of such industry, and that the extension of the period prescribed by that Act will not materially affect the question.

5. Your petitioners submit that it is to the general interests of the country, as well as to those of persons more especially interested in electric lighting, that a fair chance should be given to this industry of developing, and that the purchase option section of the Act of 1882 having been found to be a bar to all such development, it is expedient that it should be repealed, on proper provision being made for insuring that the interests of the public are duly protected, and your petitioners submit that this will be well effected by the provisions of a Bill now pending before your lordships, intituled the Electric Lighting Act (1882) Amendment (No. 1) Bill.

LEGAL.

The Bankruptcy of Bassano and Company.

In the Chancery Division of the High Court of Justice on Friday, before Mr. Justice Pearson, another question in the proceedings between the United Telephone Company and Messrs. Bassano and Slater came up for decision. The defendants were manufacturers of telephone materials at Derby, against whom the United Telephone Company had obtained an injunction and damages for infringement of patent. The costs amounted to £1,200, which the plaintiff Company endeavoured to obtain by levying an execution, and the sheriff seized the chattels on Bassano's premises in November. Previous to this, however, Bassano and Slater had executed a bill of sale to Miss Oakes of all the stock-in-trade and plant. She had taken possession, and was carrying on the business for herself, employing the present defendants as her servants, upon a weekly wage of £2 each. The day after the sheriff took possession Bassano and Slater presented a petition in bankruptcy, and a receiver was appointed. The question now for decision was whether the property belonged to the sheriff, the receiver, or Miss Oakes.

Mr. Micklem appeared for the United Telephone Company, Mr. Yate Lee for the receiver, and Mr. A. Cock for Miss Oakes.

The JUDGE decided that the bill of sale was void, as it did not comply with the requisites of the law affecting such instruments; but he acquitted Miss Oakes of any suspicion of not having acted *bonâ fide*. The goods were, he considered, in the apparent possession of the bankrupts at the time of the commencement of the bankruptcy, and, therefore, they belonged to the receiver.

COMPANIES' MEETINGS & REPORTS.

The Eastern Extension, Australasia, and China Telegraph Company (Limited).

The twenty-fifth ordinary general meeting of this Company was held on the 14th inst. at the City Terminus Hotel, Cannon-street, London, under the presidency of John Pender, Esq.

The SECRETARY (Mr. F. E. Hesse) read the notice convening the meeting and the minutes of the last general meeting, which were confirmed by the present meeting and signed by the Chairman as correct. The report of the Directors, which has appeared in *The Electrician*, was taken as read.

The CHAIRMAN: Before putting to the meeting the resolution which I shall have to propose, I will, as usual, make some remarks on the report. I daresay you will all agree with me that the report is a very full and complete one. There is scarcely a detail connected with the working of the business in the last six months respecting financial matters which is not embodied in the report; but on an occasion like this—at these half-

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yearly meetings—I think the more information we can give to the shareholders upon the general working of the Company the greater will be the confidence that will exist between the shareholders and the Board of Directors. The gross receipts for the half-year amounted to £247,017, against £248,087 for the corresponding period of 1884, or a decrease of £1,070. During the first part of the half-year the receipts compared very favourably with those of the corresponding half-year; but in November they began to fall off, and large monthly decreases have had to be reported ever since, as shown by the following figures:—In November, 1885, the receipts were £40,427, against £42,286 in the same month of 1884, or a decrease of £1,859, and in December, 1885, they were £34,785, against £41,426 in December, 1884, being a decrease of £6,641. In January of the present year our receipts were £39,699, while in the same month of 1885 they were £44,144, a decrease of £4,445; in February of this year they were £33,688, against £40,114 in February, 1885, or a decrease of £6,426; and in March of this year they were £37,804, against £46,193 in the same month of 1885, or a decrease of £8,389. These are important decreases, and no doubt you will probably ask me if I can give a reason why they should have taken place. I have often said at these meetings that trade influences our receipts very materially, and that war influences them to a very great extent; and the best explanation I can offer to account for this large falling off of revenue is that during the long period of depression of trade from which nearly all industries in the world have severely suffered, the Eastern and this Company were not affected as might have been expected, owing to exceptional causes, which have now ceased to operate, namely, the Egyptian campaign, to which New South Wales sent a contingent, and the more recent expedition up the Nile, which largely added to our traffic. There was also the Afghan frontier dispute, which led to a considerable amount of telegraphing all over our system, and consequently our receipts during 1884 and 1885 showed substantial increases over previous years when business was more flourishing. During the last few months, however, there has been no startling event to provoke the sending of telegrams, and we have therefore felt the effects of the general depression, from which we had happily so long escaped. This, I believe, is a temporary reduction. Telegraphy is certain to go on. Trade may be sick for a short time, but it never dies. With the revival of trade I expect to see a revival in our returns. The working expenses for the half-year have amounted to £71,473, against £79,496 for the corresponding period of 1884, or a decrease of £8,023, which is principally attributable to the smaller quantity of cable used in effecting repairs during the period under review. The net revenue for the half-year amounted to £130,185, against £124,228 for the corresponding period of 1884, or an increase of £5,957. Comparing the figures for the whole year, the results are as follows:—The revenue in 1885 was £506,493, while in 1884 it was £485,759, giving an increase of £20,734 for the year. The expenses for 1885 were £145,891, while in 1884 they were £146,154, showing a decrease of £263. One interim dividend at the rate of 5 per cent. per annum has been paid for the past half year, and another will be distributed to morrow, together with a bonus of 2s. per share, making a total payment for the year of 7 per cent. [applause]. The reserve fund has been increased during the half-year by £47,818, and now stands at £565,644, or equal to about 22 per cent. of the share capital. I have received letters from two or three shareholders in reference to the report. It is very remarkable that out of our large constituency—scattered all over the country—I have not received more. They are all complimentary, but one of them asks me to give some special answer as to the reserve fund. Now, gentlemen, the policy that we are pursuing as far as possible is to make your property a sound and permanent investment [applause]. You cannot have, as the saying is, a dividend and your property increasing in value at the same time. I mean to say that by a large reserve fund you place your property in a strong position. You are getting a moderate but a satisfactory dividend I hope, and at the same time your property is increasing in value I may say every six months. We wish to maintain the Company in that position, because, as I shall have occasion to tell you by and by, there are threatened oppositions. These oppositions we shall require to meet, and I think you will all agree that we shall fight better, if it is necessary to do so, if we have a substantial amount in our exchequer. I may also mention that many of our cables have been laid for a very considerable period. We do not wish to add to our capital. We wish to maintain our system by making renewals as far as we can out of income; and, if we can only maintain our cables in an efficient way out of income, depend upon it it is better for the interests of all concerned. We are quite in ignorance of what the "life" of a cable may be. Some have extended the limit to twenty and thirty years, and it is even said a more remote period than that is possible; but this we do know, that in our system we have had to renew lately a cable which was down for only twelve years. That shows the uncertainty of this class of property, and until we know more about it, I think it is better for the shareholders and all concerned that we should go on increasing our reserve fund.

A Shareholder: Can you tell us where that cable was?

The Chairman: Yes, between Singapore and Batavia. Against the revenue for the past half-year, the following sums have been charged for strengthening and improving the Company's system, namely:—Balance of cost of Singapore-Saigon and Penang-Rangoon cable renewals, £2,692. Then there was the cost of duplicating the Victoria-Tasmania cable, £31,190, and the cost of a small connection, &c., in China, £2,193, making a total of £36,076, which we have practically expended in the strengthening of our system. It has also been found necessary, in consequence of the frequent interruptions of late years, involving costly repairs, to replace the Singapore-Penang (old) section with a new brass-ribboned cable. On a previous occasion I showed you that in the amounts we were paying for repairs there would be a very considerable saving by our putting down a new cable rather than go on with that annual expense. We have had to fight the teredo. You see we have to fight both at the bottom of the sea as well as on the surface; but I think we have shown that so far we have mastered the teredo. The new brass-ribboned cable, to replace this Singapore-Penang section, will leave in the Telegraph Construction Company's ss. "Seine" in a few days. By this means it is hoped that a considerable saving will be effected under Abstract "C." A large proportion of the old line will probably be picked up, and after it has been overhauled and put into good order will be taken into the company's stock of spare cable at Singapore. The cable steamer "Recorder," built to replace the ill-fated ss. "Magneta," has safely arrived at her station at Singapore, and has relieved the ss. "Agnes," which is now on her way home for repairs. The "Recorder" encountered exceptionally severe weather when passing through the Bay of Biscay, but sustained very little damage. Her cost has been written off against the maintenance ships' reserve fund, as shown in the published accounts. You see that we are not adding to our own capital; but we are adding immensely to the power and efficiency of our property as a whole [applause]. I will now touch upon a question which I daresay you are all, more or less, interested in—I refer to the negotiations which have been going on for some time in the Australian colonies in regard to a reduction of tariffs. It will be seen from the report that the Company have decided to make substantial reductions in the rates both to Australia and China, to take effect from the 1st July next, when the Berlin Convention comes into force. We had to fight a hard battle at Berlin in the interest of the companies, and I hope that it has not been fought without success. Our object has been to meet our promises to the full extent; at the same time, while satisfying the public, to protect the interests of our shareholders [applause]. For Australia we are going to reduce the rate from 10s. 8d. to 9s. 4d. a word, and for China we are going to reduce the rate from 8s. 4d. to 7s. 1d. We had hoped that the negotiations with the Indian Government would have resulted in the lowering of their high transit rate, so that the larger reduction for Australia of 2s. per word as proposed at Berlin might have been brought about. Unfortunately, however, our efforts in this direction were not successful, and consequently we had to negotiate with the Australian colonies on a fresh basis, as it was out of the question for the Company to bear the whole of the heavy loss which the 2s. reduction would have involved, without some assistance from India or the colonies. Since these remarks were written we have received a letter from the Indian Government opening, I hope, negotiations again with a view to a better arrangement of traffic across India, and at lower rates. If those negotiations should terminate successfully it will lead to a further reduction to our Australian colonies. The decision to reduce by 1s. 4d. was arrived at after considerable negotiation with the Agents-General of the Colonies. In fact, the suggestion came from one of the Agents-General, and we are always prepared to act upon any suggestion that we consider practical and beneficial to both parties concerned. We agreed to the 1s. 4d. reduction unconditionally, and to reduce the rate by a further 1s. 4d. provided all the colonies would join in the subsidy which we now enjoy of £32,400 a year and extend for a further six and a quarter years. The subsidy has about fourteen years to run, and we proposed that if they extended it, and made it twenty years from the present time, we would make this further reduction of 1s. 4d., making in all 2s. 8d. This would give the Company time to recoup the loss that might be sustained from the reduction in the event of the reduced tariff not recouping us to the extent necessary. I may mention that most of the present subscribing colonies were prepared to agree to this arrangement—that is New South Wales, South Australia, and Western Australia; but Victoria is still in doubt. We are, however, hopeful that the arrangement may eventually be carried out; and if so, it will be very largely beneficial to the telegraphing public, and I think will place the Company in a very secure position as against any loss from the reduction. I am about to give you the figures which will show that it was only reasonable to ask for some such assistance from the colonies. We have been blamed for not giving them the whole reduction without any reference to our income or means to do so. It is very well for people to ask for this benefit; but there are always two to a bargain, and I hope we shall always be able to show that any bargain we may make we shall be able to justify, and that it is made not only in the interests of the telegraphing public, but in the interests of the shareholders. The estimated loss by the reduction of 1s. 4d. for Australia is £20,000, and by the reduction of 1s. 3d. for China £22,000, being together £42,000. That is what we have to meet at the present time. The further 1s. 4d. for Australia, if the Company's proposal is accepted, would represent an additional £20,000. In other words, we should have to face a loss of £62,000; but we should have as against that the £32,400 a year for six years. As I have said, our proposal was recommended by the Agents-General more or less warmly. Others wished to consult the Governments they represented before expressing their views. But on the whole it was well received by the Agents-General in London. Queensland and New Zealand, however, have refused to entertain it on the ground that the rate ought, in their opinion, to be only a fraction of the present charge, and that they were not prepared to take any action that would tend to discourage the establishment of an opposition cable. Queensland, apparently, has never forgiven us for connecting our system with the South Australian lines instead of joining on to their system, and notwithstanding the many attempts we have made to conciliate her she still evinces uncompromising hostility towards us. Only recently we offered, at our own expense, to connect her system with the South Australian lines by laying a cable from the Roper River to Normanton, at a cost of something like £70,000. This would provide the colonies with an alternative land line which they have long desired, and give Queensland direct communication with Europe; but the offer was refused, Queensland contending that she ought to have an independent cable of her own. The unreasonableness of this contention is obvious

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when it is remembered that the existing cables are equal to many times the present traffic, and that Queensland's proportion is only 5½ per cent. of the whole traffic with Australia. Still Queensland desires to dictate and control the other colonies. My impression is that these colonies which have supported us, and support us so well, will refuse to be influenced by parties who appear to be largely influenced by sentiment in this matter. The proportions of the traffic are as follows:—Victoria, 30¾ per cent.; New South Wales, 32½ per cent; South Australia, 15¼ per cent.; New Zealand, 13¾ per cent.; Queensland, 5½ per cent.; Western Australia, 1 per cent.; and Tasmania, 1 per cent. Nevertheless, judging from statements that have appeared in the newspapers, it would seem that efforts are being made by persons who wish the public to believe that they are officially representing the Colonial Governments in this matter for establishing a second cable to Australia. The routes advocated are:—First, from Queensland to Ceylon, touching at Java or Timor, a length of about 4,500 knots, costing about £787,000. This, though the cheapest, is not the scheme most in favour. The second route is from Western Australia to England *viâ* the Mauritius, South Africa, and the West Coast, a length of about 14,600 knots, costing over £2,500,000. The third route is from Brisbane to San Francisco or Vancouver's Island, touching at Honolulu, Feejee, and New Caledonia, a length of about 8,000 knots, costing, say, £1,500,000. The latter seems to be preferred; but both the Mauritius and Pacific routes present exceptional difficulties in the way of enormous depths, long stretches of cable, and eventual costly repairs, while the financial aspect, under the most favourable circumstances, does not promise a sufficient return to cover working expenses, and amortization at a 5s. tariff, unless the colonies are prepared to largely subsidise the project. It is, perhaps, not quite understood that the Extension Company established their line to Australia without any subsidy whatever from our own Government, or from any of the Australian Colonies. When, however, telegraphy is once established it assumes such an important position both in politics and commerce that its continuity becomes a necessity, therefore no one line can be relied on, and consequently the policy of the Companies which I have the honour to represent has been to render telegraphy a certainty by the general duplication of the system. I think it is right to add that the leading colonies in Australia felt the necessity of continuous communication as much as we did. Frequent interruptions of our line brought this prominently to the front, and I think all honour is due to the colonies of Victoria, New South Wales, South Australia, and Western Australia, for enabling the company to provide a second communication by giving the subsidy of £32,400 per annum for 20 years. The enterprise and spirit shewn by these Colonies were never shared by Queensland, and only for a short time by New Zealand, during which she contributed to the subsidy and then withdrew. It is to me remarkable that these Governments did not see the advantage of joining with the others in accepting the Company's proposals for reducing the tariff to 8s. by sharing in the subsidy and extending it for 6½ years, as the saving by the reduction would more than counter-balance their contributions to the subsidy, namely, the saving to Queensland by the reduction would be about £4,000 per annum against a contribution of £3,100. To New Zealand a saving of £10,600, against a contribution of £5,700. Consequently they would be better off by £900 and £4,500 respectively if they joined in the company's scheme. Now, I say it is unreasonable for them to refuse to join in such an arrangement. The idea is that if they come into this combination they would build up a great monopoly, and by establishing another cable they would create competition that must eventually benefit the colonies. I have had some experience in competition in submarine cables, and I can tell you that they are probably, of all things, a system which ought, more or less, to be exempted from competition. The present cables can carry a great deal more—four times as much—traffic as Australia is likely to provide for some years to come. The effect of the introduction of another company subsidised by Governments would be that neither would pay. It would be a serious loss to the colonies as regards subsidy, and a serious loss to us in our income. We have that exemplified in the case of the Atlantic cables at the present time. There is only a certain amount of telegraphy that you can rely upon every year. If a new company gets in they may obtain their proportion of the traffic, or even at first more than their proportion, as they come in under the pretence of their going to lower the rates; but the result is and always must be that the public must pay for the competition. I believe the present rates in the Atlantic are so unremunerative that the next movement must be a considerable advance, following on a very considerable reduction in the rates. In making the reductions which I have mentioned, I wish to show you that your Board are doing everything they possibly can to conciliate the different Governments of the Australian colonies. We are anxious that there should be a federation in regard to telegraphy. There is a talk of federation in regard to the colonies for great political purposes. If they quarrel with this small matter of telegraphy, I see very little hope of a grand scheme of federation being carried out. Still, I believe this, that these colonies are governed by men of great enterprise and experience, and that the small jealousies which exist at this moment, even against telegraphy, will by perseverance and conciliation be brought to an end, and that we shall eventually enjoy the confidence of the non-contributing colonies, as we do the confidence of the contributing colonies, and in that case I have no fear for the future. There is one question I would refer to to show our efforts at conciliation. Our subsidy of £7,500 per annum, payable by the Governments of New Zealand and New South Wales, in respect of the New Zealand Cable, expired the other day. We pointed out that the traffic had developed very slowly, and that after ten years' working, the traffic without the subsidy only gave an average nett return on the capital invested of 3 per cent., without putting by anything for amortization and for cost of repairs. If this had been done the return would have been insufficient to meet working expenses. The New South Wales Government agreed to renew the subsidy for a further term of ten years, on condition that the Company made certain reductions in the local tariff, but the New Zealand Government would only agree to a renewal for five years, which we did not see our way to accept unless it formed part of the larger subsidy proposal. Subsequently the New Zealand Government endeavoured to induce the New South Wales and Queensland Governments to join them in laying an opposition cable between Sydney and New Zealand, but their efforts have not so far met with any success. We had contemplated at the time the subsidy ceased raising the tariff to make up the loss of subsidy, but as this would have caused inconvenience to the telegraphing public of both colonies, we have intimated that the Company will not make any alteration in the rates before the 1st July next, by which time we hope some satisfactory solution will be arrived at. Speaking of opposition schemes to Australia, which probably are intended to benefit the promoters quite as much as the colonies, and about which considerable animus has been shown by some of those who have been disappointed—a short time ago, during my absence abroad, when the approval of a concession by the Government for a cable to the West Coast of Africa came before the House of Commons, a concession which had occupied quite two years to negotiate, and which negotiations were in the hands of the Liberal, then the Conservative, and again the Liberal Government, and probably no bargain was ever more carefully considered in the interest of a Government than this particular concession—nevertheless, the Government and myself were taxed with dishonesty in the transaction. Both the Liberal and Conservative members of the Governments, however, so completely answered the insinuations that it leaves me nothing to say about the impotent and abortive attack, excepting this—that one of the speakers let the cat out of the bag when he said that if the concession were approved, then a proposal which he had in view for connecting Australia by the West Coast of Africa could not be adopted. He made a personal attack simply because he found that the House was going to accept a fair, moderate, and reasonable concession. He saw it was going to blast his hopes of the work he had in view. This particular concession is the one to which I have just referred, viz., 14,600 knots. Our negotiations with the Colonial Governments are still progressing, and I am not without hope that they will lead to the full reduction of 2s. 8d. per word to Australia. At the last meeting I referred to the probability of a rate of 2s. 8d. per word being introduced for Press messages exchanged with Australia. Unfortunately difficulties have since arisen to delay its introduction, one being that the Indian Government made their consent conditional on the application of the reduced tariff to all the Australasian colonies instead of to the four colonies who contribute to the Company's subsidy of £32,400 per annum. This question has, however, been referred to the Governments of the contributing colonies, and we are now awaiting their decision. Now, gentlemen, I think I have given you a very large amount of information. You know pretty well what is going on at the present time. But I would just before I conclude say that it is our object, if we possibly can, to come to such an arrangement with the Australian colonies as will give them a very considerable reduction. At the same time it must be based on the principle that will protect the interests of the shareholders. I think I have shown you that what we are doing is practically in the interests of those who are most opposing us. With these remarks I beg to move the following resolution:—"That the report and accounts of the Directors now submitted be received and adopted, and that a dividend be now declared of 2s. 6d. per share, together with a bonus of 2s. per share, both free of income tax, payable on the 15th inst., making, with the previous distributions, a total payment of 7 per cent. for the year 1885."

The Right Hon. Viscount MONCK: I beg to second the motion.

The CHAIRMAN: If any gentleman has any questions to ask I shall be glad to answer them before I put the resolution.

Mr. SURTEES: Will you be kind enough to reply to one question? This is the first half-year that I have been a shareholder of this Company, and I do not follow as well as the older shareholders the form of your abstract "D"—the account of the reserve fund. I notice that the amount expended is £537,000. I do not know whether those investments have been valued at the price of the present day, or whether it means that that is what those investments have cost, or whether it means that they have been purchased without reference to the amount that is now proposed to be carried to the fund, namely, £39,000 odd? The amounts here do not tally.

The CHAIRMAN: The figures of the investments show what is invested. The difference between the two amounts is more or less floating. You will find, for instance, traffic and other debit balances £105,657, loans on deposit £80,000, cash at the bank £36,000, and so on.

Mr. SURTEES: I did not know whether the values are those of the present day.

The CHAIRMAN: What we give in the first column is the value of the stock, and in the other column is what we paid for it. We find, taking a balance occasionally, that we are considerably on the right side.

Mr. JOHN NEWTON: May I ask why you did not print in your report the drawn numbers of the bonds that are to be paid off? I think that shareholders will find after six months have elapsed that their bonds are drawn off six months before, and they lose six months' interest. That is unsatisfactory. If you put it into the report it has also the advantage of showing to the shareholders, those who had not the bonds as well as those who had, that you are reducing the debentures.

The CHAIRMAN: I do not think there can be any real reason for not putting it into the report. We have still a spare sheet left, and may as well occupy it. It is our desire to give the shareholders every possible information. We shall take notice of the point.

Mr. NEWTON: May I ask whether the reserve fund, which is so substantial, will be available for fighting purposes in the remote

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future, because I do not think competition is likely to come upon us for many years, and probably the impending fight in the Atlantic will show the evils of such competition. I should like to ask you whether the reserve fund is available for this purpose, so that if you have to fight at a future time the shareholders' interests during the struggle will not suffer. Can you utilise your reserve fund not only for renewals, but for securing the shareholders' dividend during the period of struggle?

The CHAIRMAN: I think I made a remark in the course of my few observations that we could fight all the better for having a good round sum in the exchequer.

Mr. NEWTON: Yes, that prompted my remark.

The CHAIRMAN: It is not a question to decide now. When the time comes to fight, if it ever does, we shall use our reserve fund in the best way to defend the Company's interests.

A SHAREHOLDER: It is the Company's standing army.

Mr. HEIRON: With respect to the possibility of having to meet competition, may I ask if steps have been taken to establish a new company for that purpose?

The CHAIRMAN: From my observation, and from all I can learn, I think there is no fear of a company being formed to oppose us at the present moment. I do not believe the colonies will give any subsidy for the purpose. They will be very much better off to use the money in reducing our tariffs, than in subsidising a competing line. There are, however, men at work now, and as long as there are men who think they can turn a penny you will find them at work—they have been at work to my knowledge for a great many years—but as far as I can learn there is no immediate prospect of any money being got to lay down cables to Australia and China.

Mr. HEIRON: That is a very satisfactory answer.

The CHAIRMAN: We are watching every movement, and are always on the alert.

Mr. HEIRON: It is said that a company has been formed already.

The CHAIRMAN: I am sorry to say that you cannot believe all that you read in print.

Mr. CUFF: You have paid for your new vessel out of the ships' maintenance fund. When do you expect to be paid for the lost vessel? And when that is done will the fund stand at something like the amount it was before we purchased this last new ship?

The CHAIRMAN: We have received the money from the insurance people, and we have spent that money on the new ship.

Mr. CUFF: In addition?

The CHAIRMAN: We had never taken anything out for the "Magneta." We should have done so if the "Magneta" had not been lost, but we got the insurance for that vessel, and that left the account pretty much as it is at the present time. He then put the motion, which was carried unanimously. Continuing, he said the next resolution is—"That the Right Hon. Viscount Monck, who now retires by rotation, be and is hereby re-elected a Director of this Company."

The Marquis of TWEEDDALE seconded the motion, which was carried unanimously.

The CHAIRMAN then proposed, "That Sir William M'Arthur, K.C.M.G., who now retires by rotation, be and is hereby re-elected a Director of this Company."

Sir JAMES ANDERSON seconded the motion, which was carried unanimously.

On the motion of Mr. WM. FORD, seconded by Mr. FULLER, the following resolution was carried unanimously:—"That Mr. Henry Dever and Messrs. Quilter, Ball, and Co. be re-elected auditors for the ensuing year at a remuneration of £100 each."

The CHAIRMAN having intimated that that closed the business,

Mr. HEIRON said: Before we separate we have one duty to perform—that is to give a vote of thanks to the Chairman and the Board for the very able and efficient manner in which they have conducted the business during the past half-year. I think a more able or a more efficient statement could scarcely have emanated from the Chairman than that which we have heard to-day. I take it that this is one of the most gigantic companies in existence—it is a very extensive Company—and as long as we have a Board who so thoroughly understand this business, and we are so ably and efficiently represented, the shareholders may rest perfectly confident that their interests will be taken care of. It is not only a question of the ability of the Directors, but they require to be gentlemen of high commercial and social standing and reputation, because they come in contact with various Governments, and the power which they exercise, owing to their influential position, is used for our advantage. I move that our thanks be accorded to the Chairman and Directors.

Mr. SURTEES seconded the motion, which was carried unanimously.

The CHAIRMAN: On behalf of my colleagues and myself I beg to return you our best thanks. I have gone perhaps more into details to-day than I should under ordinary circumstances. My reasons for doing so are that I think when there are rumours floating about regarding opposition it satisfies shareholders to have as much information as the Board can possibly give. I think the greater the confidence that exists between the Directors and the shareholders, the more able are we to carry on successfully the important duties of this Company. You have said very truly that this system extends over every part of the civilised world, and our work is not confined to Board meetings only. It is almost every half hour in the day that we are called upon to take some steps to protect your interests or develop your trade. Consequently it is no light position, but a very onerous one, to carry on, and to carry on successfully, a large submarine system such as that which is represented by the gentlemen on this side of the table. I hope we shall continue to enjoy your confidence; we shall certainly do our best to secure it.

The proceedings then terminated.

Oriental Telephone Company.

Report of the Directors for the year ended 31st December last, to be presented at the sixth ordinary general meeting of the Company, at the Cannon-street Hotel, on Tuesday, 20th inst., at 1 p.m.:—

The profit and loss account for the year exhibits a credit balance of £3,569. 17s. 6d., which shows a slight improvement on the returns of the previous year, in spite of irregularities on the part of the late manager at Mauritius, a loss on the working of the Colombo branch, together with the further heavy fall in the Eastern exchanges. The improvement is in some measure due to reductions in the London expenses. The Indian guarantees are still a very heavy burden on the resources of the Company, but full provision has been made for last year's claims in respect thereof in the item of £4,436. 3s. 5d. Although the expansion of the Indian revenues has been very slow, and some withdrawals of Exchange subscribers have taken place, owing to financial failures and the general depression of trade, on the whole the results from India are better than last year. The local companies in Bombay and Calcutta are now introducing the "Magneto" system throughout their "exchanges," and it is hoped that with a more efficient service thus provided, a considerable increase in the number of subscribers at each place will follow. From Bombay latterly the advices have been much more encouraging. Your Directors have thought it advisable to revalue the stores on hand at the various agencies, and the result is that an amount of £480. 16s. 11d. has been written off, chiefly on the value of instruments which had been sent out in the earlier days of the Company, and which have been found to be unsuitable. A sum also of £305. 7s. 11d. has been charged in respect of the Egyptian indemnity, the £1,000 reserved on this account having proved insufficient to meet the expenses in connection therewith. After writing off all the above items, the balance remaining to the credit of profit and loss is £2,292. 10s. 4d., which it is proposed to carry forward. It has been found necessary to make several alterations in regard to the management in the East, and the result has been beneficial. The question of the rights of the Company in Australasia has occupied a considerable time in the deliberations of the Board, and will continue to engage their serious attention. Your Directors are glad to be able to report an increase in the revenues of the subsidiary companies—notably in that of the Egyptian Company — the shares of which are almost entirely held by your Company. The Egyptian Company has earned and paid during the past year 5 per cent. on the issued Preferred Capital. Your Directors would point out that these shares, although of the nominal value of £5 each, are only credited in the balance-sheet at a value of less than £2. 10s. per share. In China the business has been placed on a better footing, and your Directors have accepted from the China and Japan Company £4,200 7 per cent. mortgage debentures in settlement of the balance due by that company, whose position now shows a distinct improvement. The present Board, feeling that the Articles of Association, especially as altered from the original form, place undue power in the hands of the Directors, have carefully considered the matter, and propose certain alterations giving greater influence to the votes of the shareholders, and these proposed alterations will be submitted at an extraordinary general meeting. You will be asked to authorise the payment of the expense incurred by the Committee of Investigation, amounting to £72, and whether the said committee shall receive an award for their services. The Directors retiring are Messrs. Henry Grewing and Thomas Lloyd, who offer themselves for re-election. Messrs. Deloitte, Dever, Griffiths, and Co., the auditors of the Company, retire, but offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. April 14		Business Done Week Ending April 14. Highest.	Lowest.
Anglo-American	35½,	36½	36½	35½
Do. Preferred	59,	60	59½	58½
Do. Deferred	11½,	12½	12½	11¾
Brazilian Submarine	11,	11½	11⅜	11
Cuba	10½,	11	—	—
Do. Preference	17½,	18½	17⅜	—
Direct Spanish	1½,	2	—	—
Do. Preference	10½	11	—	—
Direct United States Cable	10,	10½	10 5-16	10⅛
Eastern Telegraph	11⅞,	12⅛	12 3-16	11 15-16
Do. 6 per Cent. Preference	14⅛,	14½	14½	14⅜
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅞,	13⅜	13⅜	12⅞
German Union	9½,	10	—	—
Globe Telegraph and Trust	7,	7¼	7¼	7
Do. Preference	13½,	13¾	13 11-16	13⅜
Great Northern	14½,	15	15½	14 11-16
Indo-European	37½,	38½	38½	38½
Reuter's	6½,	6¾	—	—
Submarine	200,	210	207	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	9½,	9¾	9 9-16	9½
Western Brazilian	7⅜,	7⅞	7 7-16	—
Western Union 7 per Cent. 1st Mortgage	121,	125	122½	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Companies.	Closing Prices. April 14		Highest.	Lowest.
Consolid. Telephone and Maintenance	15-16,	1 1-16	—	—
Oriental	½,	⅝	—	—
United Telephone	12½,	13½	13½	12¾

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ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)..	3,	$3\frac{1}{2}$	---	—	---	—
Do. (fully paid)	5,	$5\frac{1}{2}$	---	—	.....	—
Hammond Light (£3 15s. paid)	1-16,	3-16	---	—	---	—
Swan....................................	1,	$1\frac{1}{2}$	---	$1\frac{1}{3}$	---	1 1-16
Maxim-Weston -----------------	$\frac{1}{4}$,	$\frac{3}{8}$	---	5-16	---	—

MISCELLANEOUS.

Telegraph Construction..............	$36\frac{1}{2}$	$37\frac{1}{2}$	---	$37\frac{1}{2}$	---	$36\frac{3}{4}$
India Rubber, Gutta Percha, and Telegraph Works ----------------	23,	24	---	23 9-16	---	23

SUBMARINE CABLES TRUST.

NOTICE IS HEREBY GIVEN that the COUPONS of the Submarine Cables Trust due on 15th inst. will be PAID on and after that date by Messrs. Glyn, Mills and Co., of 67, Lombard-street, between the hours of Ten a.m. and Two p.m.

The Coupon must be left for examination three clear days previous to calling for pyment.

LEWIS WELLS,
Secretary.

50, Old Broad-street, E.C., April 9, 1886.

THE EASTERN EXTENSION AUSTRALASIA AND CHINA TELEGRAPH COMPANY (LIMITED).

5% AUSTRALIAN GOVERNMENT SUBSIDY DEBENTURES.

NOTICE IS HEREBY GIVEN that in pursuance of the conditions upon which the above Issue was made, the under-mentioned numbers of Debentures were drawn by lot on the 12th April, at the Offices of the Company, Winchester House, 50, Old Broad-street, in the City of London, in the presence of SIR JAMES ANDERSON, the SECRETARY, and of JOHN VENN, Esq., Notary Public.

The said Debentures will be paid off at par on 1st day of July next, at Messrs. Barclay, Bevan and Co., 54, Lombard-street, E.C., after which date interest on them will cease

251 Debentures of £100 each.

15	932	1798	3019	4079	5425
34	936	1808	3026	4111	5447
38	964	1809	3102	4123	5482
46	969	1890	3156	4138	5485
60	1020	1913	3165	4141	5489
85	1063	1944	3199	4185	5588
120	1074	1945	3238	4186	5631
132	1084	2015	3265	4202	5645
147	1166	2049	3266	4216	5674
166	1201	2129	3277	4220	5683
234	1204	2165	3280	4236	5853
264	1210	2234	3309	4273	5866
280	1212	2242	3310	4397	5901
284	1257	2258	3323	4448	5910
385	1250	2264	3378	4497	5942
390	1288	2353	3385	4502	5958
400	1339	2398	3388	4520	5982
417	1343	2390	3392	4562	5987
418	1408	2422	3446	4576	5998
426	1450	2449	3488	4685	6004
442	1470	2453	3547	4745	6006
455	1475	2466	3566	4756	6044
477	1509	2493	3620	4839	6066
495	1539	2510	3664	4855	6073
503	1561	2606	3702	4864	6088
533	1596	2626	3729	4869	6096
621	1601	2633	3733	4872	6107
637	1602	2692	3740	4883	6117
682	1609	2696	3798	4892	6137
683	1623	2708	3819	4949	6140
724	1652	2712	3825	4998	6168
730	1662	2740	3827	5001	6175
777	1674	2743	3832	5078	6177
797	1691	2754	3835	5131	6210
799	1694	2780	3841	5146	6245
808	1700	2792	3892	5159	6257
822	1721	2802	3981	5179	6273
850	1722	2876	4007	5256	6294
851	1727	2884	4008	5293	6366
877	1737	2909	4037	5365	6387
910	1752	2915	4060	5370	6388
916	1794	2984	4063	5397	

Witness:
JOHN VENN,
9, Gracechurch-street, E.C.
Notary Public.

By order of the Board,
F. E. HESSE,
Secretary.

Winchester House, 50, Old Broad street, London, E.C.,
12th April, 1886.

"THE ELECTRICIAN."—WANTED, Vols. I. to X.—State price to M. P., Office of this Paper.

JOURNAL OF THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

Edited by F. H WEBB, Secretary.

No. 60, containing the INAUGURAL ADDRESS of the PRESIDENT, PROFESSOR D. E. HUGHES, F.R.S., consisting of an ACCOUNT of his RESEARCHES on the SELF-INDUCTION of an ELECTRIC CURRENT in relation to the NATURE and FORM of its CONDUCTOR; with important discussion thereon, including remarks by Lord Rayleigh, Mr. Frank Pope, Prof. G. Forbes, Dr. J. Hopkinson, Mr. Preece, Dr. Fleming, Mr. D. FitzGerald, Prof. S. P. Thompson, Prof. Ayrton, and the PRESIDENT'S REPLY, with ACCOUNT of FURTHER RESEARCHES. Together with Abstracts from various Scientific Periodicals, English and Foreign.

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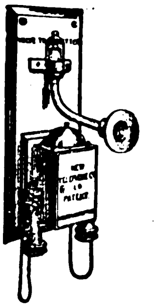

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THE

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NOTES.

URUQUAY.—The land lines in Uruguay are now restored.

PERSIAN GULF.—The cable between Fao and Bushire is interrupted.

PARA.—The cable between Maranham and Para is again in working order.

ELECTRIC LIGHTING IN AMERICA.—We learn from an American contemporary that the electric light is to be established at Jackson, Tenn.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 16th inst. amounted to £2,964.

BELGIUM.—On the 26th inst. the members of the Belgian Society of Electricians will visit the Electro-Technical Institute at the University of Liége.

THEORY OF THE TELPHONE.—M. M. E. Mercadier has contributed a very interesting article on this subject in a current number of the *Journal de Physique.*

THE THOMSON-HOUSTON ELECTRIC LIGHTING COMPANY.—We understand that the contract to light Selma, Ala., has been received by the above firm.

FRENCH ATLANTIC CABLE.—According to *The Times* New York correspondent, April 19th, a fault has occurred in this cable some 220 miles from Duxbury.

ELECTRIC LIGHTING IN COPPER MINES.—Twenty-five 2,000 candle power Weston electric arc lamps have been erected in the Osceola mill, and were lighted for the first time on the 30th March.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended 15th April are £3,327, as compared with £4,033 in the corresponding period of 1885.

EXPORTS.—The value of telegraphic wire and apparatus exported during the first three months of this year was less by £51,971 than in the corresponding period of last year, the respective values being £124,074 and £176,045.

ELECTRIC LIGHTING AT THE LEEDS TOWN HALL.—The lighting of this hall is in course of preparation. The lamps have been placed in position, and we understand that one or two preliminary trials of their illuminating power have been made.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 16th inst. were £2,466, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

CLECKHEATON.—Application has been made by the National Telephone Company for permission to erect telephone poles, the company intending to open a telephone exchange in the town. The permission for these poles was granted at the last meeting of the local board.

THE ELECTRIC LIGHTING ACTS.—The Society of Arts has presented a petition against the No. 3 Electric Lighting Act Amendment Bill (the Government Bill) and in favour of No. 1 Amendment Bill (Lord Raleigh's). The Lords' Committee will commence their inquiry on 13th May.

MADRID.—Spanish advices state that a project is under the consideration of the Provincial authorities of Madrid, for an important extension of the telegraph and telephone system, which, if carried into effect, will give that province a more complete system of official telegraphic communication than in any other part of Spain.

SALES OF PLANT.—Messrs. Wheatley Kirk, Price, and Goulty announce the sale, at an early date, of a large quantity of electrical plant, including the entire manufacturing plant, electrical apparatus, instruments, &c., of the Consolidated Electric Company (in liquidation). Further particulars will be found in our advertisement columns.

JOURNAL OF THE SOCIETY OF TELEGRAPH-ENGINEERS.—The part of the *Transactions* just issued is perhaps one of the most valuable that has ever been printed by the society, containing as it does the inaugural address of Prof. Hughes and the full discussion thereon. The paper and the critical remarks deserve long and careful study from every student.

FIRE AT LIVERPOOL TELEGRAPH EXCHANGE.—We understand that the breakdown caused by the late fire was remedied within five days, and the exchange is again in working order. Twenty miles length of wire were destroyed and eighteen hundred wires had to be cut away. Great credit is due to Mr. W. A. Sharp, the electrician, and Mr. Rowe, the engineer, for their energy in so rapidly repairing the damage.

VAPOUR FROM SECONDARY BATTERIES.—Mr. F. Higgins, in the *Transactions* of the Society of Telegraph-Engineers, suggests the use of a loose cover, such as the thinnest calico, to arrest the minute globules of acid projected into the air from secondary batteries. By this means the work in the vicinity of accumulators which are being charged is much less unpleasant, and the corrosion of metal work prevented.

APPLICATION OF ELECTRICITY TO ORGANS.—*La Lumière Electrique* states that a new organ in the Church of Nizior at Lyons is actuated by means of electro-pneumatic transmission. The system adopted is that of MM. Schmœle and Mols, of Philadelphia, and simplifies very largely the parts between the keys and the chest. The organ is really in different parts, and electricity offers the best mode of actuating the instrument.

THE WESTINGHOUSE COMPANY.—If the electric light does not develop in England by "leaps and bounds," the reason why is not far to seek. These reasons are almost absent in the States; hence we see how much more rapidly the light "goes." The Westinghouse Company have introduced modified Siemens machines and incandescent lamps. The standard lamp of 16 candle-power is guaranteed to have a life of 600 hours, with seven lamps to the indicated horse-power.

TELEGRAPHING FROM MOVING TRAINS.—Mr. L. J. Phelps, from New York, has obtained a patent for telegraphing from trains. His method is not quite the same as Edison's, the latter telegraphing from the roof of the car to wires upon folds parallel with the line, while Mr. Phelps proposes to lay a wire between the two rails and to telegraph from the bottom of the car. No doubt there is a distinction, but we fail to see that whether the apparatus is upon the roof or below the floor gives claim to a new patent.

ANTI-TRAMP PROTECTOR.—A recently-married electrician, says the *Electrical World,* who lives near Sacramento, Cal., has devised a scheme for protecting his wife from the annoyance of tramps. The vagrants invariably sought the kitchen *viâ* a rear stairway, so the electrician detached the four bottom steps from the others, and attached a powerful battery to them. A wire from the battery runs into the kitchen, and when a tramp is seen approaching all that is necessary is to touch a spring at the proper moment, and the astonished seeker after provender is thrown nearly over the back fence.

SPANISH TELEPHONE STATISTICS.—The Spanish telephone system, according to statistics just issued by the Director-General of Posts and Telegraphs, consisted on the 30th June

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last of a central station and five branches in Madrid, 517 private stations, opened by virtue of the law of 1882, and 62 private stations established in accordance with the law of 1884. The expenses of the telephone service in the first half of 1885 are returned at 280,000 pesetas, say £11,200, and the revenue £1,162 only; but it is pointed out that the materials and installations cost £7,420, the cost of erection £422, and accessories £734.

MADEIRA.—*The Monthly Correspondent* issued from this charming island contains some notes by a Hindoo, relative to his education in England, as well as other information, among which we notice that preparatory to the opening of the new African cables, two practice rooms have been opened at the Madeira Station for the learners who will be engaged at the stations. Four underground lines have been laid between the two rooms. In the rooms are Morse's ink-writers, sounders, and mirrors already fitted. Two clock-work siphon recorders are to be set up. Thus the two rooms are fair models of actual stations.

PATENTS.—Mr. Lack, the Comptroller of the Patent Office, and Mr. J. H. G. Bergne, the Superintendent of the Treaty Department of the Foreign Office, have been appointed by the President of the Board of Trade to represent this country at the third meeting of the International Conference for the Protection of Industrial Property, which is to be held at Rome at the end of this month. Mr. Lack and Mr. Bergne will be accompanied by the Master Cutler of Sheffield and Mr. Herbert Hughes, the secretary to the Sheffield Chamber of Commerce, who, from their technical knowledge, will be able to render them valuable assistance as experts.

LANCASHIRE AND CHESHIRE TELEPHONE EXCHANGE COMPANY.—This company has 1,993 miles of trunk wires, single circuit, in operation, connecting some thirty of the principal towns in the district. The public appreciation of the intertown telephone facilities provided by this company will be best judged from the fact that more than 1,500 (nearly 50 per cent) of its subscribers make regular use of the trunk wire system. The company has nearly completed the erection of Trunk wires to join up with those of the National Telephone Company's Yorkshire system. The wire used for the purpose of trunk line communication is the same as the company is gradually introducing in their local exchange system, namely, 16s hardened copper.

PORTSMOUTH.—Mr. Sandy, the local manager of the Western Counties and South Wales Telephone Company, has been explaining to the popular ear how we speak three thousand miles away. It may be hypercritical of us to say that we do not speak three thousand, although we can communicate over that distance. In his lecture, Mr. Sandy stated that the longest distance he had ever spoken was about 110 miles, from London to Norwich, and this was accomplished with perfect success. The experiments were shown to the audience, and communications were carried on between Portsmouth and Southampton. All lectures of this kind are valuable in that they are educating the public to appreciate the wonderful applications science has given to them.

GREENOCK.—A correspondent writes to the *Glasgow Herald* with regard to defective telegraphic communication at Greenock, as follows:—"Would you be kind enough to give publicity in your valuable paper to the fact that at Greenock the telegraph office is closed from 10 p.m. till 7 a.m. Greenock was thus unable within the last 10 days to receive until 7 a.m. of the following day two messages addressed, 'Steel, Greenock,' handed in at Moville at 9:45 p.m. and 11 p.m., thus preventing the steam tenders for the mails and passengers of ss. 'Circassia' and ss. 'Ethiopia' getting the necessary intimations of the times these steamers would reach the tail of the bank. The messages giving notice were despatched from Moville, but were received at Glasgow and *posted* to Greenock."

BLUE PRINTING BY ELECTRIC LIGHT.—The Western Edison Light Company of Chicago, after some experimenting, have adopted an arrangement for taking blue print by electric light, as being always ready when sun light is wanting. The apparatus consists of three hand regulating arc lamps, with carbon five-eighths of an inch diameter. The three arcs are connected in series, and the current is supplied from the incandescent dynamo which lights the company's premises. The electromotive force is 115 volts, and the current used is about 40 amperes. An iron wire resistance of 4 ohms is connected with the lamps, and thrown in when starting the current, being cut out after the light is started. A good print can be taken in 2½ to 10 minutes, a longer exposure being required for larger prints, which cannot be placed so near the light as the smaller ones.

SPANISH TELEGRAPH STATISTICS.—The official telegraph statistics of Spain for the first half of 1885 have just been published. They show that in that period fifteen new telegraph stations were opened to the public, of which seven belong to the State and eight to the railway companies, only one station having been closed. The increase of wire in the six months was 108 kilometres, bringing up the total on the 30th June last to 17,596 kilometres of line, 129 of subterranean cable, and 236 of submarine cable. The number of stations belonging to the State was 534, those of the railway companies open to the public 330, semaphoric six, municipal 16, and private one. The messages transmitted numbered 1,608,091, of which 1,245,326 were internal telegrams and 362,765 foreign. The internal telegrams comprised 164,883 official messages, 982,291 private, 38,188 private messages of the railway companies, and 59,876 service telegrams. The State revenue from telegrams during the six months was £101,000.

EXECUTION BY ELECTRICITY.—Senator McMillan, of Buffalo, U.S., has introduced in the Legislature a Bill which provides for the appointment of a commission to investigate and report the most humane method of inflicting capital punishment. The Bill is probably the result mainly of the efforts of Dr. A. P. Southwick, of Buffalo. "Dr. Southwick proposes to execute criminals by means of electricity, by which death would be instantaneous. The method which he proposes is very simple. His idea is to use an ordinary chair. In this city a wire could be run from the electric light works to the gaol. The man would sit in the chair with his head resting against its back. The wire entering an insulated substance, such as rubber or glass, would constitute the positive pole By placing the man's feet upon a metallic plate a connection would be formed with the poles. At a signal a switch in another room could be turned. The current would enter at the base of the brain, the centre of the nervous system, and pass through the man. The heart would stop beating, and a complete paralysis would ensue."

OVERHEAD WIRES.—Mr. E. Cracknell, superintendent of telegraphs for New South Wales, has proposed a plan to prevent injury from the breaking of overhead wires. He proposes to remove the wires from mid air, and to enclose them in a case resembling a frieze, to be placed close to the buildings. The frieze will be supported by pillars sunk in the ground 4ft. 6in., and 14ft. 6in. in height. Connecting these pillars are cast-iron beams 18in. wide, called friezes, and behind them are

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to be placed eight racks for holding cables, which are clusters of fifty wires embedded in an insulating substance, and coated with cement. They make a cable of 1in. in diameter. It is estimated that the rack will hold 400 wires easily. On reaching the street crossings the racks will be made to descend to the level of the road, and be carried underground to the other side, where they will rise to the previous level. A trial section of this new line is about to be erected at a probable outlay of £5,000. One objection to this plan will be urged by companies that the length of wire required in each case will be twice the length of the pillars multiplied by the number of crossings. We are almost inclined to think that an underground system would in the long run be almost as cheap as that above described.

Lighthouse Illuminants.—Mr. J. R. Wigham, in a lecture on this subject at Monkstown, stated with regard to electricity that the electric arc light was the one with which most people were familiar in this connection. In England the lighthouse stations of the South Foreland, Souter Point, and the Lizard had the electric light as their illuminant; and in France there were eight lighthouse stations at which it was used. Its power in clear weather was enormously greater than that of either gas or oil. But this extreme brilliancy was misleading to the sailor, for he could not be certain of his distance from the light; for it looked equally bright whether it was five miles or only one mile off. It was not during fine weather that one required a powerful light; for such weather a light might be too bright. Any ordinary lighthouse light would show to the horizon in clear weather; but the best lighthouse illuminant was the light which could be farthest seen in foggy weather, when the mariner most required it. It was here that the electric light failed. The greatest of all the defects of the electric light, however, was its unsteadiness, and the existence of this defect had caused the French lighthouse authorities to abandon for the present their intention of further extending the use of the light on the coast of France.

The Electric Light in Mines.—"Mr. Thomas Conelly read before the Manchester Geological Society, on March 2nd, a paper on the progress of electric lighting in mines. After giving a very careful account of the experiments which have been made, Mr. Conelly drew attention to some important facts which appear to have escaped attention. Especially he referred to the question of using the electric light in fiery collieries. He admitted that well-constructed arrangements allowed of the electric light being used with 'a moderate degree of safety right up to the face of the coal,' but he stated 'it had been found that the electric spark would ignite gas, and where there was a liability to very fiery outbursts, it was within the range of possibility that a miner might cause such an injury to the electrical arrangement as might be the cause of an explosion.' This important fact cannot be too generally known, as a considerable amount of misconception exists in relation to the electric spark and its powers." Thus far from the *Athenæum*, a contemporary that at any rate is supposed to have its intelligence well up to date. If a critic is so ignorant of what is generally known, to whom shall we look for enlightenment? In all humility we ask if there is one single word in this paragraph about which "considerable misconception exists?" The facts stated therein have been discussed a thousand times, and are as familiar to electricians as the conquest of England by William I. is to historians.

Telephonic Experiments.—During the past week the Northern District Telephone Company have opened the trunk lines between Middlesborough and Stockton and Stockton and Hartlepool. These events were celebrated by telephonic "at homes" at Middlesborough on Wednesday, Stockton on Thursday, and Hartlepool on Friday. The invitations issued by Mr. Clay, the manager of the company, were much appreciated by large audiences. The Theatre Royal at Middlesborough being connected, the performances given by the Royal English Opera Company were distinctly heard, and when it is stated that every word and note of music could be heard at Hartlepool (a distance of rather over nineteen miles) just as plainly as at the company's exchange in Middlesborough, further comment upon the excellent way in which the line has been erected is unnecessary. In addition to the Opera Company the services of several gentlemen belonging to the Telephone Company were called into play, and the musical talent developed by them, each in his own peculiar way, was extraordinary, everyone apparently being gifted with a voice of some sort, and not a few being very tolerable performers upon instruments such as the violin, flute, piano, banjo, and guitar. The greatest credit is due to all connected with the erection of these trunk lines, considering the difficulties in the route, and the bad weather experienced during the past winter, and the company may be congratulated on having such energetic and able servants as Messrs. Neave, Preston, and Bailey, the managers respectively at Middlesborough, Stockton, and Hartlepool. Mr. Clay probably derives considerable satisfaction from the verdict expressed in the local papers that "the system of the Northern District Telephone Company is as near perfect as possible."

Long-Distance Telephone Lines.—"The American Telegraph and Telephone Company," says the *Electrical World*, "organised for long-distance work, is using some of the largest cables for submarine and underground use ever laid in this country. Its entire cable equipment is of Kerite. The number of crossings between New York and Philadelphia are seven, viz., North River, twice across the Kills, Raritan, Rancocas and Delaware Rivers, and in addition an underground cable across Ridgeway Park, opposite Philadelphia. The conductors in all the cables, with the exception of one series, are composed of three No. 18 B.W.G. copper wires with Kerite insulation, measuring $\frac{9}{32}$ of an inch outside diameter, the submarine cables being armoured with eighteen armour wires, each weighing 810lb. to the mile. One cable throughout the entire series has its conductors, which are seven in number, composed of three No. 16 B.W.G. copper wires stranded together, equal in weight to 210lb. of copper to the mile, and insulated with Kerite to an outside diameter of $\frac{11}{32}$ of an inch. These in turn are taped, laid up and sewed with packing to receive nineteen No. 3 B.W.G. galvanised iron armour wires, weighing 950lb. to the mile. The entire series of cables are four in number, of seven conductors each, making a total of twenty-eight conductors. Conversation over the line is perfect, and this, to a great extent, is due to the low resistance of the conductors and their perfect insulation. It is satisfactory to know that our home manufacturers are now competing successfully with those abroad as to construction and character of submarine cables, and that even better results, both electrical and mechanical, can now be obtained in this country for both submarine and underground cables." Is not this last sentence just a "little" too showy? Surely England and Germany are still ahead, so far as submarine cables are concerned.

West Australia.—West Australia is making an effort to overtake her sister colonies in the matter of telegraphic and telephonic communication. In the small place of Honolulu the Hawaiian Telephone Company has as many as 400 subscribers, which is a paying number. If in such a place as Honolulu the

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telephone system has met with such success, there is little reason why in Western Australia it should not be received with equal favour. The Government are now taking active steps towards establishing telephone exchanges in Perth and Freemantle. They have secured the services of Mr. William J. Hancock, A.S.T.E., of Dublin, as Superintendent of Telephones, and that gentleman arrived in Perth about a month ago to commence his duties. Mr. Hancock has had considerable experience in the working of telephones in connection with the Dublin Exchange, which has about 900 subscribers, who used it to the extent of about 7,000 messages per diem. Since his arrival here Mr. Hancock has superintended the construction of telephone communication between Government House and the office of the Colonial Secretary. He is now making arrangements for the organising of an exchange in Perth and another in Freemantle. The plan to be adopted in each town is simply this:—A central office with switch room will be established, and from this will be run the wires to the subscribers, each subscriber being given a separate wire. The switchboard will be worked by girls, whose voices are better adapted to the purpose than those of boys. The duties of these operators will be simply to manipulate the switch-board so as to place any subscriber in communication with any other with whom he wishes to converse. Not a word of the conversation will be heard in the switch room. In course of time it is intended that a couple of trunk lines shall be run between Freemantle and Perth, so that the subscribers in the two towns may be able to converse with each other as occasion requires. It has not yet been decided what shall be the rent charged to subscribers, but should there be a fair number of them—say a hundred—in each town, it will probably be fixed at the low sum of £16. The telephone that will most likely be employed is the Bell and Blake instrument, which is clear speaking and rarely gets out of order. The Gower-Bell, which is chiefly used in England, is loud speaking but not very distinct. It is not expected that the exchange in either town will be established within six months; but we may mention that apparatus and material have been ordered from England.

UNDERGROUND WIRES.—"The second report of the Brooklyn Commissioners of Electrical Subways," says the *Electrical World*, "is not only an interesting document, but a valuable one, and does great credit to the intelligence and prudence of its authors. The commissioners have wisely determined to leave the work in the hands of the companies interested, and to gather experience from the results obtained by them. This is not only wise, but just, as it affords the electrical companies no ground for complaint at any subsequent failure. The Board seems to hold a favourable opinion of the creosoted wood conduit which has been in use some months in Brooklyn, but, in accordance with its plans of experiment and tolerance, has permitted the laying of Dorsett and Richardson conduits. The intelligent examination of the cables laid in the creosoted wood conduit has already brought out a fact which may prove of the greatest value in the manufacture of lead-cased cables, and which will no doubt be acted upon. Under the course which the Board is pursuing, a comparison will soon be possible of the relative advantages of air-tight and water-tight conduits and those in which the joints are not tight, and this question is becoming more and more important with the substitution of the destructive water-gas for coal-gas. Through the labours of this Board a large number of wires have already been put underground, and the end of the summer will find many of Brooklyn's most encumbered streets comparatively clear, giving Brooklyn the largest underground mileage of wire of any city in the country. In view of such real and valuable services rendered, it is hardly right that thus far the commissioners have received no compensation—a fact due to the loose manner in which the Bill creating the Board was framed. The lack of funds also prevents the employment of a competent inspector, and inspection work thus far has been done by the Board itself. This obstacle to a faithful performance of duty should be removed at once, either by the companies' action in the matter according to the provisions of the Bill, or by the State itself. Brooklyn is to be congratulated upon its advance in this matter, and we would strongly recommend the report to the attention of the New York Commission, which at present is unfortunately delayed in its action by the illness of one of its members. It is to be regretted that the report contains nothing in relation to electric light wires, but confines itself to telephone and telegraph lines. However, we are promised something about that for the future, and so must wait."

WAR OF CABLE RATES.—The Anglo-American Telegraph Company, the Direct United States Company, and the Western Union Company have forwarded us circulars to the effect that on and after the 5th May next the charge for the transmission of telegrams between the United Kingdom, France, Germany, and all the principal telegraph stations in the United States of America and Canada will be sixpence per word. Special arrangement can be made at the general offices of the company for the transmission of press messages at 3d. per word. These cable companies have our entire sympathy, for it is hard to the management and to the shareholders that after they have proved the possibilities of Atlantic telegraphy, made the first experiments from experience, introduced the necessary changes in apparatus and cables—we say it is hard that a new company should come in and lay cables that are not wanted, there not being sufficient traffic for those already laid, and try to reap some advantage by their action. It seems to us that nowadays pioneers in any direction are not appreciated; the sole aim appears to be to get rid of the pioneers, and for some one else to reap the benefit of their labours. We sincerely trust that those Americans who have dabbled in late editions of Atlantic cables will find that their fingers have been well burned for their pains. The Central News says: On Friday last an important conference was held at the offices of the Anglo-American Cable Company for the purpose of considering the advisability of commencing "a war of rates" against the Commercial Cable (Mackay-Bennett) Company. The conference lasted two hours, and the companies constituting the "pool" —namely, the Anglo-American, Western Union, Direct United States, and the French Cable Company—were fully represented; the delegates present including Mr. John Pender, Mr. von Chauvin, Mr. Fuller, M. Pouyer-Quertier, M. Riant, Mr. Underdown, Viscount Monck, Mr. F. Weaver, &c. After considerable discussion it was resolved that, as the Commercial Company persisted in their refusal to join the "pool," or to agree to an increase in the present cable rates to America, the pool companies on and from the 5th of May should reduce their charges for private despatches to sixpence per word, and for press messages to threepence per word. The drastic character of the new tariff may be gathered from the fact that the rates in operation at present are 1s. 8d. for private despatches and 10d. for press messages. The new rates will apply not only to the United Kingdom, but to messages despatched from France, Germany, &c., and the charges will include the cost of transmission to most of the American and Canadian commercial centres, for which it has hitherto been customary to make additional charge. Up to Tuesday last the Commercial Cable Company had made no move.

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ELECTROMAGNETIC INDUCTION AND ITS PROPAGATION.

BY OLIVER HEAVISIDE.

(Continued from page 387.)

Some Notes on Magnetisation.

The long delay in the publication of the last section has somewhat thrown me off the track. The revision and condensation of manuscript matter require a preliminary mental preparation. I therefore interpolate a section, intended to come later, previously written, for the most part, on a subject which has more than common interest at the present date (March 27), owing to recently-published experimental investigations. After this, I shall conclude the subject of the stresses in the briefest manner possible, by omission and abridgement.

Although it is generally believed that magnetism is molecular, yet it is well to bear in mind that all our knowledge of magnetism is derived from experiments on masses, not on single molecules, or molecular structures. We may break up a magnet into the smallest pieces, and find that they, too, are little magnets. Still, they are not molecular magnets, but magnets of the same nature as the original; solid bodies showing magnetic properties, or intrinsically magnetised. We are nearly as far away as ever from a molecular magnet. To conclude that molecules are magnets because dividing a magnet produces fresh magnets always would be clearly unsound reasoning. For it involves the assumption that a molecule has the same magnetic property as a mass, a large collection of molecules, having, by reason of their connection, properties not possessed by the molecules separately. (Of course, I do not define a molecule to be the smallest part of a substance that has *all* the properties of the mass.) If we got down to a mass of iron so small that it contained few molecules, and therefore certainly not possessing all the properties of a larger mass, what security have we that its magnetic property would not have begun to disappear, and that their complete separation would not leave us without any magnetic field at all surrounding them of the kind we attribute to intrinsic magnetisation. That there would be magnetic disturbances round an isolated molecule in motion through a medium, and with its parts in relative motion, it is difficult not to believe in view of the partial co-ordination of radiation and electro-magnetism made by Maxwell. But it might be quite different from the magnetic field of a so-called magnetic molecule—that is, the field of any small magnet. This evident magnetisation might be essentially conditioned by structure. not of single molecules, but of a collection, together with relative motions connected with the structure, this structure and relative motions conditioning that peculiar state of the medium in which they are immersed, which, when existent, implies intrinsic magnetisation of the collection of molecules, or the little mass. However this be, two things are deserving of constant remembrance. First, that the molecular theory of magnetism is a speculation which it is desirable to keep well separated from theoretical embodiments of known facts, apart from hypothesis. And next, that as the act of exposing a solid to magnetising influence is, it is scarcely to be doubted, always accompanied by a changed structure, we should take into account and endeavour to utilise in theoretical reasoning on magnetism which is meant to contain the least amount of hypothesis, the elastic properties of the body, speaking generally, and without knowing the exact connection between them and the magnetic property.

Hooke's law, *Ut tensio, sic vis*, or strain is proportional to stress, implies perfect elasticity, and is the first approximative law on which to found the theory of elasticity. But beyond that, we have imperfect elasticity, elastic fatigue, imperfect restitution, permanent set.

When we expose an unmagnetised body to the action of a magnetic field of unit inductivity, it either draws in the lines of induction, in which case it is a paramagnetic, is positively magnetised inductively, and its inductivity is greater than unity; or it wards off induction, in which case it is a diamagnetic, is negatively magnetised inductively, and its inductivity is less than unity; or, lastly, it may not alter the field at all, when it is not magnetised, and its inductivity is unity.

Regarding, as I do, the force and the induction—not the force and the induced magnetisation—as the most significant quantities, it is clear that the language in which we describe these effects is somewhat imperfect, and decidedly misleading in so prominently directing attention to the induced magnetisation, especially in the case of no induced magnetisation, when the body is still subject to the magnetic influence, and is as much the seat of magnetic stress and energy as the surrounding medium. We may, by coining a new word provisionally, put the matter thus. All bodies known, as well as the so-called vacuum, can be inductised. According to whether the inductisation (which is the same as "the induction," in fact) is greater or less than in vacuum (the universal magnetic medium) for the same magnetic force (the other factor of the magnetic energy product), we have positive or negative induced magnetisation.

To the universal medium, which is the primary seat of the magnetic energy, we attribute properties implying the absence of dissipation of energy, or, on the elastic solid theory, perfect elasticity. (Dissipation in space is scarcely within a measureable distance of measurement.) But that the ether, resembling an elastic solid in some of its properties, is one is not material here. Inductisation in it is of the elastic or quasi-elastic character, and there can be no intrinsic magnetisation. Nor, evidently, can there be intrinsic magnetisation in gases, by reason of their mobility, nor in liquids, except of the most transient description. But when we come to solids the case is different.

If we admit that the act of inductisation produces a structural change in a body (this includes the case of no induced magnetisation), and if, on removal of the inducing force, the structural change disappears, the body behaves like ether, so far, or has no inductive retentiveness. Here we see the advantage of speaking of inductive rather than of magnetic retentiveness. But if, by reason of imperfect elasticity, a portion of the changed structure remains, the body has inductive retentiveness, and has become an intrinsic magnet. As for the precise nature of the magnetic structure, that is an independent question. If we can do without assuming any particular structure, as for instance, the Weber structure, which is nothing more than an alignment of the axes of molecules, a structure which I believe to be, if true at all, only a part of the magnetic structure, so much the better. It is the danger of a too special hypothesis, that as, from its definiteness, we can follow up its consequences, if the latter are partially verified experimentally, we seem to prove its truth (as if there could be no other explanation), and so rest on the solid ground of Nature. The next thing is to predict unobserved or unobservable phenomena whose only reason may be the hypothesis itself, one out of many which, within limits, could explain the same phenomena, though, beyond those limits, of widely diverging natures.

The retentiveness may be of the most unstable nature, as in soft iron, a knock being sufficient to greatly upset the intrinsic magnetisation existing on first removing the magnetising force, and completely alter its distribution in the iron; or of a more or less permanent character, as in steel. But, whether the body be para- or dia-magnetic, or neutral, the residual or intrinsic magnetisation, if there be any, must be always of the same character as the inducing force. That is, any solid, if it have retentiveness, is made into a magnet, magnetised parallel to the inducing force, like iron.

Until lately only the magnetic metals were known to show retentiveness. Though we should theoretically expect retentiveness in all solids, the extraordinary feebleness of diamagnetic phenomena might be expected to be sufficient to prevent its observation. But, first, Dr. Tumlirz has shown that quartz is inductively retentive, and next, Dr. Lodge (*Nature*, March 25th, 1886) has published some results of his experiments on

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the retentiveness of a great many other substances, following up an observation of his assistant, Mr. Davies.

The mathematical statement of the connections between intrinsic magnetisation and the state of the magnetic field is just the same whether the magnet be iron or copper, para- or dia-magnetic, or is neutral. In fact, it would equally serve for a water or a gas magnet, were they possible. That is,

$$\text{curl.}\,(\mathrm{H}-h)=4\pi\Gamma\,; \qquad \text{div.}\,\mathrm{B}=0\,;$$

H being the magnetic force according to the equation $B=\mu H$, where B is the induction and μ the inductivity, Γ the electric current, if any, and h the magnetic force of the intrinsic magnetisation, or the impressed magnetic force, as I have usually called it in previous sections where it has occurred, because it enters into all equations as an impressed force, distinct from the force of the field, whose rotation measures the electric current. It is h and μ that are the two data concerned in intrinsic magnetisation and its field; the quantity I, the intensity of intrinsic magnetisation, only gives the product, viz., $I=\mu h/4\pi$. It would not be without some advantage to make h and μ the objects of attention instead of I and μ, as it simplifies ideas as well as the formulæ. The induced magnetisation, an extremely artificial and rather unnecessary quantity, is $(\mu-1)\,(\mathrm{H}-h)\,4\pi$.

It will be understood that this system, when united with the corresponding electric equations, so as to completely determine transient states, requires h to be *given*, whether constant or variable with the time. The act of transition of elastic induction into intrinsic magnetisation, when a body is exposed to a strong field, cannot be traced in any way by our equations. It is not formulated, and it would naturally be a matter of considerable difficulty to do it.

In a similar manner, we may expect all solid dielectrics to be capable of being intrinsically electrised by electric force, as described in a previous section. I do not know, however, whether any dielectric has been found whose dielectric capacity is less than that of vacuum, or whether such a body is, in the nature of things, possible.

As everyone knows nowadays, the old-fashioned rigid magnet is a myth. Only one datum was required, the intensity of magnetisation I, assuming μ to be unity in as well as outside the magnet. It is a great pity, regarded from the point of view of mathematical theory, which is rendered far more difficult, that the inductivity of intrinsic magnets is not unity. But we must take Nature as we find her, and although Prof. Bottomley has lately experimented on some very unmagnetisable iron, which may approximate to $\mu=1$, yet it is perfectly easy to show that the inductivity of steel magnets in general is not 1, but a large number, though much less than the inductivity of soft iron, and we may use a hard steel bar, whether magnetised intrinsically or not, as the core of an electromagnet with nearly the same effects, as regards induced magnetisation, except as regards amount, as if it were of soft iron.

Regarding the measure of inductivity, especially in soft iron, this is really not an easy matter, when we pass beyond the feeble forces of telegraphy. For all practical purposes μ is a constant when the magnetic force is small, and Poisson's assumption of a linear relation between the induced magnetisation and the magnetic force is abundantly verified. It is almost mathematically true. But go to larger forces, and suppose for simplicity we have a closed solenoid with a soft iron core, and we magnetise it. Let F be the magnetic force of the current. Then, if the induction were completely elastic, we should have the induction $B=\mu F$. But in reality we have $B=\mu(F+h)=\mu H$. If we assume the former of these equations, that is, take the magnetic force of the current as *the* magnetic force, we shall obtain too large an estimate of the inductivity, in reckoning which H should be taken as the magnetic force. This may be several times as large as F. For, the softer the iron the more imperfect is its inductive elasticity, and the more easily is intrinsic magnetisation made by large forces; although the retentiveness may be of a very infirm nature, yet whilst the force F is on, there is h on also. This overestimate of the inductivity may be partially corrected by separately measuring h, after the original magnetising force has been removed, by then destroying h. But this h may be considerably less than the former. For one reason, when we take off F by stopping the coil current, the molecular agitation of the heat of the induced currents in the core, although they are in such a direction as to keep up the induced magnetisation whilst they last, is sufficient to partially destroy the intrinsic magnetisation, owing to the infirm retentiveness. We should take off F by small instalments, or slowly and continuously, if we want h to be left.

Another quantity of some importance is the ratio of the increment in the elastic induction to the increment in the magnetic force of the current. This ratio is the same as μ when the magnetic force is small, but is, of course, quite different when it is large.

As regards another connected matter, the possible existence of magnetic friction, I have been examining the matter experimentally. Although the results are not yet quite decisive, yet there does appear to be something of the kind in steel. That is, during the act of inductively magnetising steel by weak magnetic force, there is a reaction on the magnetising current very closely resembling that arising from eddy currents in the steel, but produced under circumstances which would render the real eddy currents of quite insensible significance. In soft iron, on the other hand, I have failed to observe the effect. It has nothing to do with the intrinsic magnetisation, if any, of the steel. But as no hard and fast line can be drawn between one kind of iron and another, it is likely, if there be such an effect in steel, where, by the way, we should naturally most expect to find it, that it would be, in a smaller degree, also existent in soft iron. Its existence, however, will not alter the fact materially that the dissipation of energy in iron when it is being weakly magnetised is to be wholly ascribed to the electric currents induced in it.

P.S., April 13.—As the last paragraph, owing to the hypothesis involved in magnetic friction, may be somewhat obscure, I add this in explanation. The law, long and generally accepted, that the induced magnetisation is simply proportional to the magnetic force, when small, is of such importance in the theory of electro-magnetism, that I wished to see whether it was minutely accurate. That is, that the curve of magnetisation is, at the origin, a straight line inclined at a definite angle to the axis of abscissæ, along which magnetic force is reckoned. I employed a differential arrangement (differential telephone) admitting of being made, by proper means, of considerable sensitiveness. The law is easily verified roughly. When, however, we increase the sensitiveness, its accuracy becomes, at first sight, doubtful; and besides, differences appear between iron and steel, differences of kind, not of mere magnitude. But as the sensitiveness to disturbing influences is also increased, it is necessary to carefully study and eliminate them. The principal disturbances are due to eddy currents, and to the variation in the resistance of the experimental coil with temperature. For instance, as regards the latter, the approach of the hand to the coil may produce an effect larger than that under examination. The general result is that the law is very closely true in iron and steel, it being doubtful whether there is any effect that can be really traced to a departure from the law, when rapidly intermittent currents are employed, and that the supposed difference between iron and steel is unverified.

Of course it will be understood by scientific electricians that it is necessary, if we are to get results of scientific definiteness, to have true balances, both of resistance and of induction, and not to employ an arrangement giving neither one nor the other. He will also understand that, quite apart from the question of experimental ability, the theorist sometimes labours under great disadvantages from which the pure experimentalist is free. For whereas the latter may not be bound by theoretical requirements, and can employ himself in making discoveries, and can put down numbers, really standing for complex quantities, as representing the specific this or that, the former is hampered by his theoretical restrictions, and is employed, in the best part of his time, in the poor work of making mere verifications.

(To be continued.)

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CORRESPONDENCE.

SELF-INDUCTION OF WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We read in the pages of history of a monarch who was "*super grammaticam.*" All truly great men are like that monarch. They have their own grammars, syntaxes, and dictionaries. They cannot be judged by ordinary standards, but require interpretation. Fortunately the liberty of private interpretation is conserved.

No man has his own grammar to a greater extent than Prof. Hughes. Hence, he is liable, in a most unusual degree, to be misunderstood, as I venture to think he has been by many, including Mr. W. Smith, whose interesting letter appears on p. 455, and Prof H. Weber, p. 451.

The very first step to the understanding of a writer is to find out what he means. Before that is done there cannot possibly be a clear comprehension of his utterances. One may, by taking his language in its ordinary significance, hastily conclude that he has either revolutionised the science of induction, or that he is talking nonsense. But to do this would not be fair. We must not judge by what a man says if we have good reason to know that what he means is quite different. To be quite fair, we must conscientiously endeavour to translate his language and ideas into those we are ourselves accustomed to use. Then, and then only, shall we see what is to be seen.

When Prof. Hughes speaks of the resistance of a wire, he does not *always* mean what common men, men of ohms, volts, and farads, mean by the resistance of a wire—only sometimes. He does not equally define what it is to be when the accepted meaning is departed from. But by a study of the context we may arrive at some notion of its new meaning. It is not a definite quantity, and must be varied to suit circumstances. Again, there is his "inductive capacity" of a wire. We can only find roughly what that means by putting together this, that, and the other. It, too, is not a definite quantity, but must be varied to suit circumstances. It is not the coefficient of self-induction, nor is it any quantity defining a specific quality of the wire, like conductivity, or inductivity. It is a complex quantity, depending on a great many things, but which may, to a first rough approximation, be taken to be proportional to the time constant of the wire, the quotient of its coefficient of self-induction by its resistance. Bearing these two things in mind, we shall be able to approximate to Prof. Hughes's meaning.

Owing to the mention of discoveries, apparently of the most revolutionary kind, I took great pains in translating Prof. Hughes's language into my own, trying to imagine that I had made the same experiments *in the same manner* (which could not have happened), and then asking what are their interpretations? The discoveries I looked for vanished for the most part into thin air. They became well known facts when put into common language. The satisfaction of getting verifications, however, even in so roundabout and rough a manner, is some compensation for the disappointment felt. I venture to think that Prof. Hughes does not do himself justice in thus deceiving us, however unwittingly, and that possibly there has been also some misapprehension on his part as to what the laws of self-induction are generally supposed to be.

I have failed to find any departure from the known laws of electro-magnetism. In saying this, however, I should make a reservational remark. There may be lying latent in Prof. Hughes's results dozens of discoveries, but it is impossible to get at them. For consider what the mere existence of ohms, volts, and farads means? It means that, even before they were made, the laws of induction in linear circuits were known, and very precisely. To get, then, at new discoveries requires very accurate comparison of experiment with theory, by methods which enable us to see what we are doing and measuring, in terms of the known electro-magnetic quantities. This is practically impossible, on the basis of Prof. Hughes's papers. We can only make very rough verifications. I have had myself, for many years past, occasional experience with induction balances, of an exact nature, true balances of resistance and induction, and always found them work properly. But, in the modification made by Prof. Hughes, the balance is generally of a mixed nature, neither a true resistance nor a true induction balance, and has to be set right by a foreign impressed force, viz., induction between the battery and telephone branches. By using a strictly simple harmonic E.M.F., as of a rotating coil, we may equally formulate the conditions of the false balance, and then, noting all the resistances, &c., concerned, derive, though in a complex manner, exact information. Or, if we use true balances, any kind of E.M.F. will answer.

To illustrate the falsity of Prof. Hughes's balances and the difficulty of getting at exact information he finds the comparative force of the extra currents in two similar coils in series to be 1·74 times that of a single coil. From the context it would appear that this comparative force of the extra currents is the same thing as the former inductive capacity of wires. Now, the coefficient of self-induction of two similar coils in series, not too near one another, is double that of either, whilst the time constant of the two is the same as of either. This can be easily verified by true balances.

The most interesting of the experiments are those relating to the effect of increased diameter on what Professor Hughes terms the inductive capacity of wires. My own interpretation is roughly this. That the time constant of a wire first increases with the diameter, and then later decreases rapidly; and that the decrease sets in the sooner the higher the conductivity and the higher the inductivity (or magnetic permeability) of the wires. If this be correct, it is exactly what I should have expected and predicted. In fact, I have already described the phenomenon substantially in this journal; or, rather, the phenomenon I described contains in itself the above interpretation. In *The Electrician* for January 12, 1884, I described how the current starts in a wire. It begins on its boundary and is propagated inward. Thus during the rise of the current it is less strong at the centre than at the boundary. As regards the manner of inward propogation it takes place according to the same laws as the propagation of magnetic force and current into cores from an enveloping coil, which I have described in considerable detail in this journal. The retardation depends on the conductivity, on the inductivity, and on the section, under similar boundary conditions. If the conductivity be high enough, or the inductivity or the section be large enough, to make the central current appreciably less than the boundary current during the greater part of the time of rise of the current, there will be an apparent reduction in the time constant. Go to an extreme case. Very rapid short currents, and large retardation to inward transmission. Here we have the current in layers, strong on the boundary, weak in the middle. Clearly, then, if we wish to regard the wire as a mere linear circuit, which it is not, and as we can only do to a first approximation, we should remove the central part of the wire—that is, increase its resistance, regarded as a line, or reduce its time constant. This will happen the sooner the greater the inductivity and the conductivity, as the section is continuously increased. It is only thin wires that can be treated as mere lines, and even they, if the speed be only great enough, must be treated as solid conductors. I ought to also mention that the influence of external conductors, as of the return conductor, is of importance, sometimes of very great importance, in modifying the distribution of current in the transient state. I have had for years in MS. some solutions relating to round wires, and hope some day to arrive at them in the course of the paper I am at present publishing, or rather, not publishing, as the editor has been able to afford so little space for it lately.

As a general assistance to those who go by old methods, a rising current inducing an opposite current in itself and in parallel conductors, this may be useful. Parallel currents are said to attract or repel, according as the currents are together or opposed. This is, however, mechanical force on the conductors. The distribution of current is not affected by it. But when currents are increasing or decreasing, there is an apparent attraction or repulsion between them. Oppositely going currents repel when they are decreasing, and attract

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when they are increasing. Thus, send a current into a loop, one wire the return to the other, both being close together. During the rise of the current it will be denser on the sides of the wires nearest one another than on the remote sides. It is an apparent force, not between currents (on the distance action and real motion of electricity views), but between their accelerations.—Yours, &c., OLIVER HEAVISIDE.

April, 17, 1886.

A CORRECTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I regret to find that I have made a slip in the working at the latter part of my article on "Ring Armatures." This I now hasten to correct.

In the expression for the polar surface for one side face of the square core, a printer's error of qd^2 for q^2a occurs. My mistake follows in the simplification, which should be

$$\frac{m\,\pi}{360}(2\,q+1)a$$

instead of

$$\frac{m\,\pi}{360}(2q\,\sqrt{a}+a)$$

This correction modifies some of the following results, viz.: —The total surface for the square core becomes

$$\frac{m\,\pi}{180}(3\,q+2)a$$

which, taking $q=\cdot 5$ afterwards works out numerically to 182·9 square inches, being 75 per cent. greater than the corresponding surface for the cylinder ring. Also the value for γ at which the two surfaces are equal, becomes

$$\gamma=\frac{3\,q+1}{q}$$

I shall feel obliged if you will insert this correction in your next issue.—Yours, &c., GUY C. FRICKER.

London, S.W., April 17th, 1886.

ELECTRIC LIGHTING BY MEANS OF LOW-RESISTANCE GLOW LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the paper on this subject read by Mr. Alexander Bernstein before the Society of Electricians, and published in your issue of the 2nd inst., the author described an ingenious switch, intended, amongst other things, to render impossible the "long-closing" of a lamp circuit in which a break of continuity should have occurred whilst "short-closed." But it would be *at least* as probable for such a break to occur in a lamp circuit when long-closed as when short-closed; and, indeed, more so, for assuming the lamps to last 1,500 hours, and working only 500 hours per annum on an average, each of these 300 lamp cut-outs must act once every three years or one every three or four days. Does Mr. Bernstein rely on the "infallability" of his cut-outs for keeping the circuit continuous? If so, I think he will find that, like a certain dignitary residing at Rome, they are only "human" after all. —Yours, &c., J. W. KEMPSTER.

Venice, 13th April, 1886.

RESISTANCE CURRENT AND E.M.F.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am just beginning to learn something of electrical science, but at the outset am very much puzzled by an inability to understand the real physical concomitants or aspects of the fundamental notions implied in the terms resistance, current, and electromotive force. The former I can see has somewhat the nature of "molecular inertia"—that is, on the assumption of electric force being manifested in the shape of molecular motion or vibration. But the only way to regard the two latter on the same hypothesis is to suppose them somewhat similar respectively to the amplitude and wave length of such a molecular vibration as that of a ray of light.

Current, for instance, seems to me to be well represented or measured by the amount or extent of motion to right or left in one plane, supposing the obverse to be in the axis of the wave motion and facing the direction in which the latter travels. Electromotive force would then be represented in direct proportion (as the last) by the distance between successive wave-tops, or by what engineers would call the "pitch."

I fear that your readers who are advanced in the subject will consider my ideas, to say the least, somewhat "loose," but I should be grateful for any hints from them as to the true way in which physically to regard an electrical vibration or current, whether it be rectilinear or in the shape of a wave, as I have assumed.

Thanking them and you in advance,—Yours, &c.,

Manchester, 19th April, 1886. STUDENT.

PARALLEL DISTRIBUTION BY TRANSFORMERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of March 26th, I find a letter by Messrs. Zipernowsky, Deri and Blatly, in which they say that the system of connecting the transformers in branch circuits was patented to them. I was somewhat surprised at this statement, but on reference to their Patent Specification, No. 3,379, of 1885, I find that it is really substantiated by their second claim, which is as follows:—

"In the application of induction coils or transformers for alternating electric currents, the arrangement of several stations of second order as branch circuits of the main line, *i.e.*, connecting up the local centres with the main line in multiple arc, to which main line is supplied an alternating electric current of a tension as constant as possible, substantially as described and shown in Fig. 4."

Now, for several years past, electricians and manufacturers have used electrical apparatus connected in branch circuits for industrial purposes, such as dynamo machines, telegraphic and physical apparatus for electrolytical and metallurgical purposes, arc lamps, incandescent lamps, &c., and it would be interesting to know whether in the face of this fact, the use of parallel branch circuits for exciting transformers can form the subject of a patent according to English law.

Any information on this subject by your readers will greatly oblige.—Yours, &c., MERCURIUS.

Cologne, Germany, April 19th, 1866.

PRIMARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We beg you will allow us to give the following public reply to Mr. Verity's letter of last week, which may possibly interest other readers.

We have repeatedly used primary batteries for both temporary and permanent installations during the last three years. For the former they are very handy up to, say, 60–80 lamps of 10–12 candle-power each, as they do not need a dynamo to recharge them, and the solution is easily obtained.

We have before us a list of the installations erected to run permanently, and the following are examples. For obvious reasons we give no addresses, but may mention that we shall be pleased to give them to any one desirous of verifying our statements:—

No. 1. Installation of 50 lights, consisting of 10 candle-power and 16 candle-power incandescent and one arc lamp running since October, and lately increased to 80 lights.

No. 2. Bank in London; 34 lights, been in operation for eighteen months.

No. 3. Residence at Blackheath; 23-25 lights, including billiard table lamps, using 54 cells, lighting all lamps at one time; been in operation eighteen months. Commenced with 16 cells and 15 lights.

No. 4. Mr. M———, Atherstone, used all last hunting season 28–30 lights; running now six months.

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Sussex-villas, W. ; 22 lights and 16 cells been working eighteen months.

Sir F. ———— ; 20–25 lights, for three to four months, 16 cells.

Mr. W. ————, Lee; 12–16 candle-power lamps for the last twelve months.

Experimenting with this battery a short time ago an arc lamp taking 12 amperes ran 17½ hours perfectly, the carbons then being consumed. Last month we ran 25 Swan lamps for temporary installation for three evenings of 5-6 hours each, with one usual charging; 38 cells were used, and lamps were 8-10 candle-power.

After adopting these batteries, the invention of Mr. G. C. V. Holmes, for such extended use, we are still of opinion that they afford the happiest solution for lighting small detached residences, and trust you may find a corner for this.—Yours, &c., LAING, WHARTON, AND DOWN.

8 and 9, Holborn-viaduct, London, E.C., April 21st.

N.B.—A number of trials of these batteries for special purposes have lately taken place, the complete success of which leads us to believe that a vast field for their employment is about to open, in which they will stand without a rival.

HYPNOTIC EFFECT OF THE ELECTRICAL CURRENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It would be very interesting if any of your readers would publish in your Correspondence columns their experience in the use of electricity to cure sleeplessness. The details, viz., E.M.F. and kind of cell used, the means of making contact and the direction of current, ought to be fully given.—Yours, &c.,

Clapham, April 17, 1886. F. W.

RESISTANCE COILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Has it ever been noticed that by altering the three coils in the "A" arm (n = R A/B) to legal units, the bridge measures resistances in L. U without further change? The fact is, of course, obvious when pointed out; but I do not think it has been, and it saves a good deal of trouble.—Yours, &c.

C. W. S. C.

WHAT IS ELECTRICITY?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to my letter published in your number of the 9th current, I have some further facts on this subject which call for attention. MM. Cailletet and Bouty described before the Paris Academy of Sciences "numerous experiments made with mercury, silver, tin, aluminium, magnesium, copper, iron, and platina, proving that the electrical resistance of these metals decreases regularly when the temperature is lowered from 0° to – 123° C., and that the coefficient of variation is apparently much the same for all." They further stated that "it seems probable that the resistance would become extremely slight at temperatures lower than 200°, but they had not carried their experiments so far." The action of the freezing mixture of – 123°C. on a copper wire would be twofold: — *First*, the normal amount of latent heat within the wire would be greatly reduced. *Second*, the molecules of the copper would be drawn closer together. Notwithstanding that the molecules of the copper would be drawn closer together, and thereby leave less space between or around them for the passage of the electricity, yet the resistance to the passage of the electricity through the wire was diminished by the removal of part of the latent heat that was within the copper. This proves that heat is in some way the obstructing element which prevents the free passage of electricity through metals.

There is another important phenomenon bearing on this subject. In the *Scientific American* of the 27th ult. there is a letter to the editor from a Mr. Charles L. Chapin, giving an account of certain engineering operations he was shown in Bermondsey when he was in this country in January, 1874. All persons acquainted with engineering know how much time and labour are required in the operation of fixing on the face plate of a large turning lathe the pieces of metal which are either to be turned or bored. A Mr. Werdermann formed the idea and patented the plan of fixing these pieces of metal by means of powerful electro-magnets. These large magnets were arranged on the face-plate of the turning lathe, so that when a piece of metal to be turned or bored was placed in its proper position on the face plate, the electricity was then switched on to the electro-magnets, and they advanced and held the piece of metal firmly without any other fastenings, thereby saving much time and labour. Owing to this invention a discovery was made of a phenomenon which Mr. Chapin says has remained unexplained until now, and he has given the information to the editor of the *Scientific American* in hopes that an explanation will be found. Every scientist knows that Count Rumford's attention was first directed to the study of heat by the very great amount of it which is produced at the boring of a hole through a mass of metal. In the engineering shop in Bermondsey Mr. Chapin saw masses of iron bored and turned, during which processes neither the bored and turned iron, nor the chips from them, showed signs of heat, and the tools used in doing the work of turning and boring were so cool that they did not require to have a stream of water kept running on them, as is commonly necessary when this work is done by the common kind of turning lathes. At the end of Mr. Chapin's letter he writes: "Mr. Werdermann's solution of the matter was simply—It was supposed that the heat of the cutting-tools was absorbed by the magnetised condition of the iron which formed the keeper of the heads of the magnets." Mr. Chapin adds in his letter: "Was this the true solution?" I reply, it is so far true; but it does not explain why these iron electro-magnets should absorb an amount of heat which could not be absorbed by much larger masses of unelectrified iron. The reason why that large amount of heat disappeared was on account of the attraction which electricity has for heat. The currents of electricity passing through the wires of the electromagnets absorbed all the free heat which came within their reach from the metal when the boring and turning was taking place, and kept the tools cool in consequence. This discovery of the late Mr. Werdermann places beyond all doubt the fact of the great attraction which electricity has for heat.

Whether electricity and heat be or be not each of them a kind of imponderable matter, it is manifest from the facts narrated in this and my previous letter, that electricity and heat are each distinct and separate elements, which cannot be transformed into one another, as has been previously supposed to be the case, in accordance with the theory of energy, as at present promulgated.—Yours, &c. JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, 10th April, 1886.

THE POLARITY OF TADPOLES.—The following, says the *Centrablatt für Elektrotechnik*, is reported about an interesting experiment of the physiologist, Prof. L. Herman. In a flat bowl filled with water, in which a number of 14-days' old frog-larvæ (of *rana temporaria*) were disporting themselves, were sunk along the narrow side ready for an experiment thick zinc wires connected with a battery of 20 little zinc carbon elements. When the current was made the whole of the little animals fell into a wriggling motion, which soon ceased. But all the larvæ without exception had taken up one position, in which the head was turned to the anode and the tail to the cathode. The animals remained in this position till the current was again broken, when they again fell into the wriggling motion, but now less violently. Repeated experiments proved that the living animals showed a decided polarity, placing themselves along the stream lines of a current with their heads all in one direction, this direction being reversed when the commutator was reversed—that is, the current was reversed. An explanation of this interesting phenomenon has not hitherto been given.

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THE ELECTRICIAN.

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CITY AND GUILDS OF LONDON INSTITUTE.

The Report of the Governors of this important Institute for the year ending December, 1885, has just been issued, and is, on the whole, highly satisfactory. So far as it relates to the metropolis, the document is chiefly interesting from the evidence it affords of the unabated enthusiasm of the promoters, and the undiminished liberality of the patrons. Of the latter, the paragraph which we published a fortnight ago detailing the additional sums of money voted for the purposes of this Institute by the CITY GUILDS is a striking proof, not merely of the munificence of these ancient associations, but of their just appreciation of the duties devolving upon them in modern times. Judged by their deeds in England, Mr. HEALY'S Irish description of them as "Skinners and Salters" sounds like a grotesque libel. In answer to a recent appeal the various Companies interested in the Technical Education of British artisans have just increased their annual subscription by nearly £5,000, and their special grants are on an equally magnificent scale.

Handsome as are the endowments for this and its affiliated institutes in London and the provinces, they by no means exceed the requirements. The original outlay has been very great, and the cost of maintaining these establishments at a high standard of efficiency is necessarily very heavy. So far from begrudging the expense, we rejoice that it has been incurred, for it is the best security that the work will be carried out on the lines originally laid down, and on a scale commensurate with the objects to be achieved. A year ago we had to regret that the advantages of the undertaking were not being recognised by those whom it was intended to benefit as rapidly as we could wish; but there were signs of steady improvement even then, and last year's report shows that this improvement is going on at an accelerated rate. It will take some time to convince the working classes of this country, both masters and men, that their surest prospect of successfully competing with the manufacturers and artificers of foreign countries is to beat them in scientific knowledge and technical skill. Indications are not wanting that this lesson is being surely, if slowly, mastered; and we may confidently anticipate that the extensive provisions already made for supplying existing deficiencies in these respects will not long be in excess of the demand.

The CENTRAL INSTITUTION in London is now nearly completed. A good beginning has already been made in the higher branches of applied science, and in July next it is intended to start a more extended course of Technical Instruction there for Teachers, to whom lectures will be given, with laboratory instruction on special branches of technology. Prof. W. E. AYRTON, F.R.S., has been appointed to this institution as head of the electrical engineering branch, his place at the FINSBURY TECHNICAL COLLEGE having been taken by Prof. SILVANUS P. THOMPSON, late of University College, Bristol. Nearly £80,000 has been spent on the building of the CENTRAL INSTITUTE, a further sum of nearly £18,000 being expended on its fittings and apparatus. It is estimated that not less than £10,000 will be required, in addition to the students' fees, to meet the annual charges. Every year's increase, however, in the number of students will tend not to increase the required subsidy, but rather to diminish it. At present their contributions cover but a small proportion of the expenses.

Large as is the cost of this establishment, it is, we are reminded, not nearly so great as that of similar technical colleges of France and Germany. The new buildings of the ECOLE CENTRALE at Paris, designed with a like object to these in London, have now been completed at a cost of £260,000; and on the new Polytechnic school in the capital of the German Empire a sum of £340,000 has been expended. These vast establishments have been partly aided from private and public sources like our own, but largely also by the State, which in this country has contributed nothing. We differ in this respect from most of the Continental nations, a fact which indicates how much more they realise the value of higher technical instruction as an aid to national prosperity than do the statesmen of the British Empire. Speaking of the British Empire, we are glad to notice that an application has been received, which will no doubt be favourably considered, from the Board of Technical Education, NEW SOUTH WALES, for the extension of the Institute's examination to that colony. A federation of this kind will at least form one more link in the friendly bonds which unite the mother country to her children in far-off lands.

It must be borne in mind also when the expenses of these Central Institutions are in question that not nearly all the money is spent upon themselves. In the metropolis alone their grants to University College and King's College, for furthering the objects of the undertaking, amount to £800 a year; and to the Horological Institute, and the School of Art Wood Carving, further sums of £350 and £250 respectively were granted last year. Turning to the provinces, the Sheffield Firth College receives £300 per annum for five years, and Manchester and Nottingham have received £200 and £300 respectively for the past year. The cost of the Classes and Technological Examinations amounts to £3,517, and the greater part of this is of course drawn by the provinces, where it is gratifying to note that technical instruction is spreading rapidly in every direction. Much, if not the greater part, of this instruction is probably given in after-work hours. We infer this from the success of the evening classes at the London Finsbury College, where by far the most numerous attendance is in the evening; and where the receipts from fees alone amount to a very respectable sum. At this, as at similar institutes in the country, the study of elec-

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trical science holds a very high position. Next to cotton manufacture in special districts, and mechanical engineering and carpentry generally, electrical engineering attracts the greatest number of candidates for examination. In this subject, as in nearly all the rest, the proportion of failures last year was less than formerly, showing that the character of the instruction is improving with the increasing facilities afforded for the training of competent teachers.

Altogether the City Guilds have reason to be proud of the work they have set on foot, and have good ground for hope that their efforts will in due time be amply rewarded in a widespread elevation of the standard of workmanship in British industrial pursuits. Their case is so good, their objects being so definite and so distinct from anything else in the field, that they have only to advocate it on its merits to ensure a favourable response. Nothing will be gained, however, we venture to remind the Governors, by exaggeration, or by setting their scheme in opposition to or rivalry of other systems of education which have a totally different aim. One of the speeches at the presentation of prizes last December seems to call for this warning. A certain Right Honourable informed the audience, with much oratorical embellishment, that for his part he was prepared to say that anyone who receives the good education that this Institute will give has got as gentlemanlike an education as he would get in archaic subjects, in Latin and Greek, and, what is more, he has got an infinitely more useful education. This eloquent personage had satisfied himself, or, at least, said he had, that what is called the liberal education of a gentleman is only "the study of antiquated ideas," which are past and done with. Those who applauded these words will see, we hope, on reflection, that a Technical Institute will not be benefited by half-truths or whole falsehoods such as these. Lord CHESTERFIELD told his son that he must learn Latin and Greek because they were the accomplishments of a gentleman; he did not say that a gentleman may not study technicology. If we do not like the gentility associated with Latin and Greek we had better say nothing about gentility, and stick to technicality. But perhaps after all the speaker we have referred to was only a chance comer, who, having nothing better to say, thought to flatter an assemblage of working men by telling them how gentlemanly they were in comparison with himself.

AN ABSOLUTE ELECTROMETER WITH CONTINUOUS INDICATIONS.*

The author says:—"We have constructed an electrometer, founded on the attraction of two concentric cylinders, and allowing the measurement of potentials in absolute value. This electrometer has the double advantage of being very easily constructed, and of giving continuous indications.

"An insulated cylinder, A A, is joined to the source whose potential it is desired to measure. A cylinder, B, whose axis is coincident with that of the first cylinder, is suspended by means of a stalk, I, to the plate P of a balance, and communicates with the earth by means of the beam of the balance. This cylinder is partly plunged in a cylindrical vessel, C, of rather larger diameter, and communicating likewise with the earth. A screen, E E E, communicating with the earth, allows the stalk I to pass through an opening; it serves to protect the balance against the attractions of the cylinder A A."

The cylinder B is pushed upward with a force which may be compared with that of gravity by putting weights on the scale-pan P and restoring it to its original position.

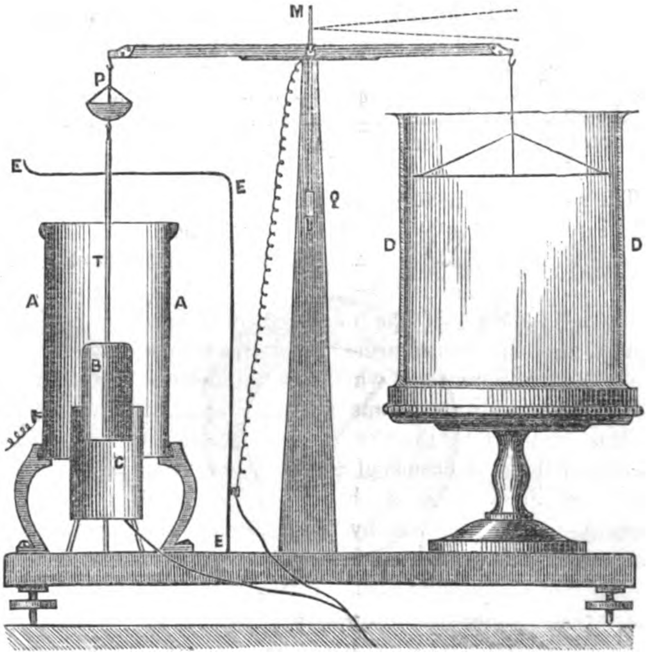
"To deaden the oscillations of the beam in the place of the second scale-pan is suspended a large cardboard disc which can rise and fall in a cylindric glass vessel, DD, of rather large diameter. The friction of the air renders the apparatus nearly dead beat."

To obtain the difference of potential V between B and A we have the formula

$$V^2 = 4\ F \log \frac{R}{r}$$

where F is the force pushing the cylinder B upwards (of course this is the weight in the scale pan $\div g$), and R and r are the respective radii of the cylinders A and B. The theory whence this formula is obtained may be found in Clerk Maxwell's large work, Vol. I., Art. 126. The theory of the quadrant electrometer is a modification of the same thing.

"The force F being between extended limits, independent of the position of the cylinder B, it follows that the instrument may also be used without employing weights and by simply observing the inclination of the beam. A mirror, M, fixed above the knife edge, allows this inclination to be measured by the method of reflection. When equilibrium is obtained, F is equal to a constant multiplied by the tangent of the angle of inclination. This constant is determined once for all by placing in the pan P a known weight, when the electrometer is discharged, and observing the corresponding deviation."



Bichat and Blondlot's Absolute Electrometer.

A counterpoise, Q, movable along a needle perpendicular to the beam, permits the sensitiveness to be modified at will.

It can be shown that the force F is not materially affected by a small lateral displacement of the axis of the cylinder B.

If we take into account the action of the stalk we have

$$V^2 = 4\ F \left\{ \log. \frac{R}{r} - \log. \frac{R}{e} \right\}$$

where e is the diameter of stalk.

* Note of MM. E. Bichat and R. Blondlot, presented by M. Lippmann at the Academie des Sciences meeting of March 29th, 1886.

NEW VOLTMETER AND AMMETER FOR CONTROL IN WORKING.*

Fig. 1 (Fig. 138 *C. E.*) shows the external form of the instrument. The round box B contains a coil and the rest of the apparatus described below. This is fastened to a mahogany slab A, which in its turn is fastened to a vertical wall by the screws *a* and *b*, the upper edge being kept carefully horizontal by means of a level.

* From the "Institute of Physics and Mechanics," of Dr. M. TH. Edelmann, at Munich, in the *Centralblatt für Elektrotechnik*, No. 7, Vol. VIII.

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The essential parts are shown in Fig. 2. (Fig. 134). These are—three pieces of thin sheet iron, *m*, *n*, *p* ; the coil R, which surrounds two of the pieces of sheet iron, *m* and *n*. The piece *p* is outside the coil, and curved concentrically with it. The current which flows through the coil magnetises these three pieces of iron, of which *m* and *p* are fixed, while *n* can turn round an axis. To *n* is attached a weight, *g*, to regulate its motion, and the sensitiveness of the instrument can be increased or diminished by means of a screw, *r s*, which alters the position of the centre of gravity of *g*. The position of *n* is indicated on the scale by the pointer *z* ; *e* and *f* are the binding screws to connect the coil with the battery or dynamo.

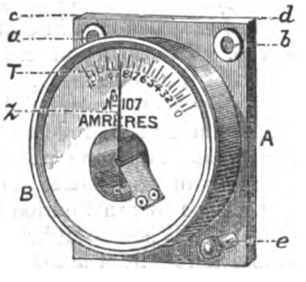

FIG. 1.

So long as the magnetising effect of the current is small, and consequently *m* and *n* close together, the repulsion between *m* and *n* is the principal force under consideration, and their magnetisation increases with the current strength. But this magnetisation will soon reach its limit, and then the attraction between *n* and the coil and between *n* and *p* will be the effect which will predominate ; *p* also acts as a shield to protect *n* from external magnetic action.

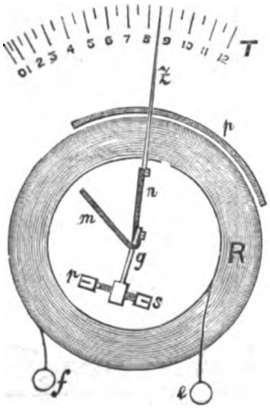

FIG. 2.

In Fig. 3 (Fig. 135) we have a curve showing the connection between current-strength and the twist of the needle. This is straight between certain limits, and it is between these limits that measurements are to be taken by the instrument.

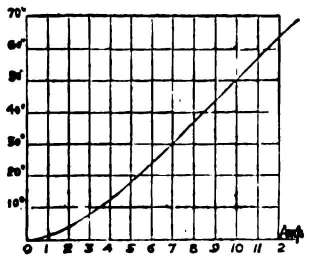

FIG. 3.

The lines of force of a coil are not in its plane, but parallel to its plane, and therefore to plane of paper. The equipotential surface which passes through the coil is in the same plane as coil—that is, it coincides with plane of paper. From the Figs. 136, &c., with their description, you would infer that the lines of force lie in the plane of the coil, and the equipotential surfaces are to parallel plane of coil and paper, which is certainly not the case. If you consider A and B as sections of the coil parallel to its plane, the lines of force are somewhat as roughly shown, and the equipotential surfaces are parallel to the force lines.

(The pieces of iron have the lines joining their poles parallel to plane of paper, not in it.)

ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 440.)

Now if σ be the specific resistance of the conductor, σu equals the electromotive force parallel to the axis of x, so that

$$\sigma u = -\frac{d\phi}{dx} - A^2\frac{dU}{dt};$$

so that by the preceding equations

$$\frac{\sigma}{4\pi}\left\{\Delta^2 U - (1-k)\frac{d^2\phi}{dx\,dt}\right\} = -\frac{d\phi}{dx} - A^2\frac{dU}{dt},$$

with similar equations for V, W. The quantities U, V, W and their first differential coefficients with respect to x, y, z are continuous, and these equations enable us to find them if we know the value of ϕ, the potential of the free electricity. Helmholtz shows that the whole energy in the field due to the currents may be written

$$\frac{A^2}{8\pi}\iiint\left\{\left(\frac{dU}{dy}-\frac{dV}{dz}\right)^2+\left(\frac{dW}{dz}-\frac{dW}{dy}\right)^2+\left(\frac{dW}{dy}-\frac{dU}{dz}\right)^2 + k\left(\frac{d\phi}{dt}\right)^2\right\}dx\,dy\,dz,$$

so that if k be negative, this expression may become negative, and in that case the equilibrium would be unstable ; hence we conclude that only those theories are tenable for which k is positive.

The equations written above are those which hold in a conductor, in an insulator the equations are

$$\nabla^2 U = (1 = k)\frac{d^2\phi}{dx\,dt}$$

$$\nabla^2 V = (1-k)\frac{d^2\phi}{dy\,dt}$$

$$\nabla^2 W = (1-k)\frac{d^2\phi}{dz\,dt}$$

$$\nabla^2\phi = 0.$$

Von Helmholtz shows that in the conductor the electrostatic potential ϕ satisfies the equation

$$\nabla^2\left\{\phi + \frac{\sigma}{4\pi}\frac{d\phi}{dt}\right\} = A^2 k\frac{d^2\phi}{dt^2},$$

so that if the conductor has an infinitely small resistance, the equation becomes

$$\nabla^2\phi = A^2 k\frac{d^2\phi}{dt^2}.$$

This represents a wave motion, the velocity of propagation of which is $1/A\sqrt{k}$. If k, as in Neumann's theory, be equal to unity, then the velocity of propagation is $1/A$, and from the value of A, found from experiments on the force between circuits conveying currents, this is nearly equal to the velocity of propagation of light. Thus, according to Neumann's theory, in a perfect conductor an electrostatic disturbance is propagated with the velocity of light. In an insulator ϕ satisfies the equation

$$\nabla^2\phi = 0;$$

and this represents a motion propagated with an infinite velocity, and thus according to this theory, an electrostatic disturbance is propagated with an infinite velocity in a perfect non-conductor. In an imperfectly conducting substance the velocity of propagation of a wave notion would depend upon the length of the wave.

Let us now go on to consider, what, according to this theory, are the forces acting on an element of circuit conveying a current. Let us suppose that the element ds forms an element

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of a circuit through which a current ι is flowing; then the energy of the circuit will be

$$A^2\int\iota\left\{U\frac{dx}{ds}+V\frac{dy}{ds}+W\frac{dz}{ds}\right\}ds.$$

In order to find the force parallel to x, let us suppose that each element of the circuit receives an arbitrary displacement x, parallel to the axis of x; then the alteration in the energy will be

$$A^2\int\iota\left\{\frac{dU}{dx}\frac{dx}{ds}+\frac{dV}{dx}\frac{dy}{ds}+\frac{dW}{dx}\frac{dz}{ds}\right\}\delta x\,ds+A^2\int\iota U\frac{d\,.\,\delta x}{ds}ds.$$

Integrating the second term by parts, we see that it may be written

$$[A^2\iota U\delta x]-A^2\int\iota\left\{\frac{dU}{dx}\frac{dx}{ds}+\frac{dU}{dy}\frac{dy}{ds}+\frac{dW}{dz}\frac{dz}{ds}\right\}\delta x\,ds.$$

Substituting this value for the second term, we see that the alteration in the energy,

$$=[A^2\iota U\delta x]+A^2\int\iota\left\{\frac{dy}{ds}\left(\frac{dV}{dx}-\frac{dU}{dy}\right)-\frac{dz}{ds}\left(\frac{dU}{dz}-\frac{dW}{dx}\right)\right\}\delta x\,ds;$$

hence we see, by the Conservation of Energy, that there is a force on each element of current parallel to the axis of x equal to

$$\iota\left\{\frac{dy}{ds}\left(\frac{dV}{dx}-\frac{dU}{dy}\right)-\frac{dz}{ds}\left(\frac{dU}{dz}-\frac{dW}{dx}\right)\right\}A^2,$$

and by symmetry forces parallel to y and z equal respectively to

$$\iota\left\{\frac{dz}{ds}\left(\frac{dW}{dy}-\frac{dV}{dz}\right)-\frac{dx}{ds}\left(\frac{dV}{dx}-\frac{dU}{dy}\right)\right\}A^2;$$

$$\iota\left\{\frac{dx}{ds}\left(\frac{dU}{dz}-\frac{dW}{dx}\right)-\frac{dy}{ds}\left(\frac{dW}{dy}-\frac{dV}{dz}\right)\right\}A^2,$$

so that the resultant of these forces is at right angles to the element. In addition to these forces there are other forces at places where the quantity ιU is discontinuous, or, since U is continuous, at places where ι is discontinuous, whose components parallel to the axes of x, y, z, are respectively

$$A^2 U\,\delta\iota,\qquad A^2 V\,\delta\iota,\qquad A^2 W\,\delta\iota;$$

but $\delta\iota$ equals de/dt, the rate at which the free electricity is increasing at the place, so that we have at any place where the free electricity is changing a force whose components are

$$A^2 U\frac{de}{dt},$$

$$A^2V\frac{de}{dt},$$

$$A^2W\frac{de}{dt}.$$

We saw before that the force acting on the circuit per unit length is at right angles at each point to the element of circuit at that point, so that, unless a circuit includes places at which the quantity of free electricity is changing, the circuit will behave as if it were acted on by forces which were everywhere normal to the elements on which they act. In the experiments which have been made to test whether the force on the element is at right angles to it, there have been no points where the free electricity is changing, so that these experiments do not contradict Neumann's theory, although, according to it, the force on an isolated element is not necessarily at right angles to that element, for in addition to the forces normal to the element we have forces equal to $A^2U de/dt$, $A^2V de/dt$, $A^2W de/dt$ parallel to x, y, z respectively, acting at the ends, the resultant of these two forces is a force whose components parallel to the axes of x, y, z are respectively

$$\frac{A^2\,de\,dU\,ds}{dt\,ds}$$

$$\frac{A^2\,de\,dV\,ds}{dt\,ds},$$

$$\frac{A^2\,de\,dW\,ds}{dt\,ds},$$

and as these forces are not necessarily at right angles to the element, the resultant force is not necessarily so; the effect of these forces could not, however, be detected unless there was a discontinuity in the current.

V. Helmholtz in the memoir,* which we have already quoted, shows that, according to his extension of F. E. Neumann's theory, the forces between two elements of circuit ds and ds' may be looked upon as made up of—

(1) A repulsive force on ds due to an end of de', equal (per unit length) to

$$-A^2\iota\frac{de'}{dt}\frac{1}{r}\frac{dr}{ds};$$

(2) A repulsive force on ds due to ds', equal per unit length to

$$-\frac{A^2\iota'}{r^2}\left\{2\cos(ds\,ds')-3\cos(r\,ds)\cos(r\,ds')\right\};$$

(3) A repulsion between the ends of ds and ds', equal to

$$-\frac{1}{2}(1+k)A^2\frac{de}{dt}\frac{de'}{dt};$$

(4) A repulsion on ds', due to an end of ds equal per unit length to

$$-A^2\iota'\frac{de}{dt}\frac{1}{r}\frac{dr}{ds}.$$

The second of these is the only one considered in Ampère's theory. We must remember in calculating these forces that each element has two ends.

Let us now go on to find the couples acting at each point of the circuit. If the tangent to the circuit makes an angle of θ with the axis of z, and the plane containing the tangent and the axis of z an angle ϕ with the plane xz, then we may write

$$\frac{dx}{ds}=\sin\theta\cos\phi,$$

$$\frac{dy}{ds}=\sin\theta\sin\phi,$$

$$\frac{dz}{ds}=\cos\theta,$$

so that with the same notation as before the energy equals

$$A^2\int\iota\left(U\frac{dx}{ds}+V\frac{dy}{ds}+W\frac{dz}{ds}\right)ds$$

$$=A^2\int\iota\,(U\sin\theta\cos\phi+V\sin\theta\sin\phi+W\cos\theta)\,ds,$$

so that if ϕ increases by $\delta\phi$, the alteration in the energy equals

$$A^2\int\iota\,(-U\sin\theta\sin\phi+V\sin\theta\cos\phi)\,\delta\phi\,ds,$$

so that the couple tending to increase ϕ, *i.e*, the couple whose axis is parallel to the axis of z, equals

$$A^2\iota\,(V\sin\theta\cos\phi-U\sin\theta\sin\phi)$$

per unit length of current; this may be written

$$A^2\iota\left(V\frac{dx}{ds}-U\frac{dy}{ds}\right),$$

hence the couples parallel to the axes y and x are by symmetry respectively

$$A^2\iota\left\{U\frac{dz}{ds}-W\frac{dx}{ds}\right\},$$

$$A^2\iota\left\{W\frac{dy}{ds}-V\frac{dz}{ds}\right\}.$$

The axis of the resultant couple is perpendicular to the element and to the vector whose components are U, V, W.

In another paper† Von Helmholtz discusses the force acting per unit of volume on a conductor traversed by electric currents; he shows that, according to the potential theory, if u, v, w are the components of current through an element $dx\,dy\,dz$, and X, Y, Z the components of the force acting on this element of volume per unit of volume, then

$$X=A^2\left[v\left(\frac{dV}{dx}-\frac{dU}{dy}\right)+w\left(\frac{dW}{dx}-\frac{dU}{dz}\right)+U\frac{de}{dt}\right]$$

* "Ueber die Theorie der Elektrodynamik," dritte Abhandlung, Crelle, LXXVIII. pp. 273, 324, 1874; "Gesammelte Werke," p. 723.

† "Ueber die Theorie der Elektrodynamik" Crelle, LXXVIII. pp. 273-324, 1874 *Gesammelte Werke*, Vol. II. p. 703.

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$$Y = A^2\left[u\left(\frac{dU}{dy}-\frac{dV}{dx}\right)+w\left(\frac{W}{dy}-\frac{dV}{dz}\right)+V\frac{de}{dt}\right]$$

$$Z = A^2\left[u\left(\frac{dU}{dz}-\frac{dW}{dx}\right)+v\left(\frac{dV}{dz}-\frac{dW}{dy}\right)+W\frac{de}{dt}\right]$$

He then discusses the application of the potential law to sliding contacts—that is, contacts such as those made by a wire dipping into mercury; in the derivation of the forces from the potential law it is assumed that the displacements are continuous, and it might be objected that we have no right to apply the law in this case, as the motion of the wire and the mercury seems at first sight discontinuous. Von Helmholtz, however, points out that, as the wire carries the mercury with it as it moves, the motion is not really discontinuous and that Neumann's law is applicable. The question of sliding contacts comes prominently forward when we compare the various theories; we shall return to it again in this connection.

Von Helmholtz also in this paper investigates the electromotive forces acting on a conductor in motion; he shows that if the components of the velocity of the conductor at any point are α, β, γ, then P, Q, R, the components of the electromotive force, are give by the equation

$$P=\beta\left(\frac{dU}{dy}-\frac{dV}{dx}\right)+\gamma\left(\frac{dU}{dz}-\frac{dW}{dx}\right)+\frac{d}{dx}(U\alpha+V\beta+W\gamma),$$

with similar equations for Q and R.

He also investigates the difference between the results of Ampère's and Neumann's theory for the E.M.F. due to induction. The results are complicated; for practical purposes it is sufficient to notice that when there is a mechanical force tending to make the body move in a certain direction, there must be an E.M.F. when the body moves in that direction.

C. Neumann's Theory.

C. Neumann assumes that the electric potential energy is propagated with a finite velocity, and that if two electrified bodies are in motion, the mutual potential energy is not ee'/r, where r is the distance between them, but ee'/r', where r' is the distance between them, at a time t before, where t is the time taken by the potential to travel from the one body to the other.

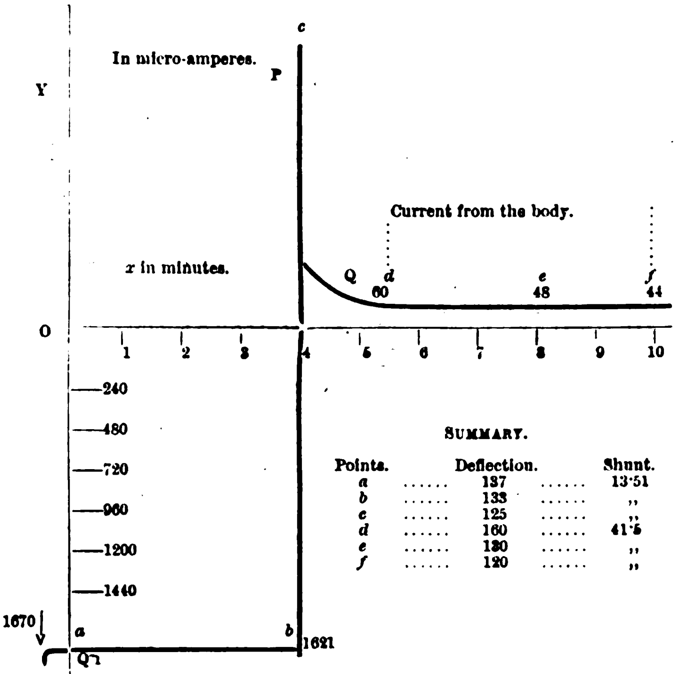
The energy considered in C. Neumann's theory is a kind of energy quite different from any that we have experience of; it is not potential energy, because that at any time depends only on the position of the system at that time; it is not kinetic, because that depends only on the position and velocity of the system at the time under consideration, whilst Neumann's energy depends on the velocity and position of the system at some previous time. In spite of all this, however, Neumann applies the ordinary dynamical processes to this energy just as if it were kinetic or potential; and in this way arrives at the same expression as Weber for the force between two moving electrified bodies. The rest of the theory is the same as Weber's, except that Neumann's assumption about the nature of a current is different from Weber's. According to Weber, an electric current consists of equal quantities of positive and negative electricity, moving with equal velocities in opposite directions. According to Neumann, the positive electricity alone can move, the negative being attached to the molecules of the conductor. Riecke and Clausius have shown that with this assumption and Weber's law a steady current must exert a force upon a particle at rest and charged with electricity, and must in consequence produce an irregular distribution of electricity over any conductor in its neighbourhood.

(To be continued.)

ELECTRICAL CONDITIONS OF THE HUMAN BODY.

LECTURE II.

Dr. Stone: Mr. Vice-President and gentlemen—In the first lecture I made some observations as to the resistance of the human body. I took it that it has been enormously over-estimated, and that the first difficulty was due to the fact that insufficient contacts had been obtained. I showed also a system by which a sufficient contact could be obtained. I ought to have mentioned that I verified the fact that skin resistance was entirely eliminated upon the corpse. After taking the observations I spoke of with the wetted poles, I thrust two long silver needles into the feet of the dead body, and took another determination, and it came out; although the needles were thrust into the muscular tissue, the resistance was higher than what I had had before. I then showed that another difficulty was due to the fact that the human body rapidly electrolyses, and that a current of polarisation is set up, which is of very considerable power. That topic I wish to go into more closely to-day. I indicated the direction in which it is best to take the current—from hand to hand, from foot to foot, and from hand to foot, and through other parts. I observed, too, that the size of the patient did not seem to make any great difference in the resistance, because tall men gave, if anything, a lower rather than a higher resistance than short men, the physiological law clearly coming out as the length of the lever in a body so is the area of the muscles that move it. I gave certain examples, and I mentioned an interesting determination which I had been able to make with the assistance of Mr. Lant Carpenter. To-day I do not wish to speak of the electrolytic action which takes place when a current passes through the body. Now, all fluids are electrolytes, and it is somewhat difficult to measure their resistance in every case. So are bodies imbibed with fluid, and on this subject there have been made exhaustive researches—a long one by Du Bois Reymond; and I mentioned another one, which I shall refer to again, by the Count du Moncel. In the next place I shall show that the current that has to be taken back again was an ordinary fluid resistance which has been charged in the usual way. I will now charge and discharge two little cells connected by a fine tube, which may be looked upon as a sort of electrical schema of the human body. [Experiment.] In this case the resistance is about 1,340 ohms, and the solutions which I use are the same as those which I made use of before. This is only a tube of salt and water about 2 millimetres in diameter, yet it takes fully 10 minutes to charge it, and even then with difficulty. It is easy enough to see the effect by a sensitive galvanometer, and I hope that I shall be able to demonstrate it. But I must wait some little time until it is properly charged, and in the meanwhile I will make some further remarks. This polarisation, of course, appears as an increased resistance, and, besides the Count du Moncel's observations, there is an excellent paper on the subject by Drs. Waller and de Watteville in the *Philosophical Transactions* for 1882, which I shall have to quote presently. I found when I came to make these charging and discharging observations that two things happened. There is an initial throw, and the galvanometer gives a great start, and then it permanently remains deflected. At first I attributed this initial start to something of the nature of a condenser action, and I stated this fact at the meeting of the British Association at Aberdeen. I have been led by Prof. Hughes's researches to somewhat modify my views on this subject since then, and I wish only to mention that I think it might better be designated under the name of self-induction, which I shall speak of slightly to-day. At the third lecture I shall show that the self-induction takes place during variable periods of current, and that with this constant current it is not very visible. This galvanometer is only intended to show the permanent deflection. Now, this counter-electromotive force is considerably greater than I had anticipated. Presently I shall give you a very excellent measurement, made independently of myself, and which is represented by the two curves on the diagram in the gallery. The upper curve shows very beautifully what happens. The first part of the curve below the line in the middle is the period of discharge. All the measurements are given. Then the discharge takes place where that vertical line is. The galvanometer shoots up to the point C, and comes down again, but not to the line of zero.



SUMMARY.

Points.	Deflection.	Shunt.
a	137	13·51
b	133	,,
c	125	,,
d	160	41·5
e	130	,,
f	120	,,

On the contrary, it remains steadily, and for a very considerable time—very much longer than I anticipated—discharging through the galvanometer without losing its charge. In that case there are ten minutes given, and the fall in the current I shall speak of presently. In many cases I have been able to produce a much larger effect

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than that. That is intentionally taken with a small current, so that we shall be able to measure it with a not very delicate galvanometer. But where you use a larger electromotive force the quantity discharged is very considerable. I therefore will mention some cases in St. Thomas's Hospital, where electricity administered was not purely for experimental, but for electro-therapeutical purposes. The first is a case of sciatica. The patient was very much atrophied in the leg, and, consequently, the resistance was somewhat high. It was about 1,900 ohms. I charged him for 30 minutes with 10 bichromate cells from foot to foot, putting the proper pole to the diseased limb, which, I may incidentally remark, resulted in a cure. But when I discharged through a galvanometer I had to somewhat reduce and modify the indications. The first throw was not less than 250 scale divisions—a very large throw indeed. I then discharged the lead poles, to see if they were doing this work, and they gave hardly any deflection at all. They gave only 20 scale divisions, so that it was actually the patient, and not the electrodes, which were charged. I then passed the same charge through a condenser with a ⅓-microfarad capacity, and I got a scale deflection of 30, and somewhat more than the poles gave me, but infinitely less than came through the patient. That was the first case. In the second I gave a constant current of 14 volts for half an hour from forehead to both feet immersed in a vessel of water. This was a case of diabetes, and you are perhaps aware that Dr. Mariano Semmola has proved that there is a decided decrease of sugar under the influence of a constant current. The resistance here was only 600 ohms, obviously because the conductor was duplicated. I corrected this by Sir Henry Mance's method, and the resistance came down to 543 ohms. There was a polarisation current of no less than 137 ohms representing all that amount of difference. The third case which I have to quote was another case of diabetes, in which the resistance was taken in the same way, but only with 6 volts from forehead to both feet. The man could not stand more, for he was extremely ill, and, indeed, eventually died. There I got 1,100 ohms, but corrected by Sir Henry Mance's method it came down to 1,025 ohms, of which the polarisation current represented no less than 145 ohms. This is a very large counter electromotive force, and much larger proportionately than would be expected and more than was demonstrated before. I will discharge this little schema of an electrical man through the galvanometer, but I am afraid it will not be a great resistance, the quantity is so very small—but I think it is visible. [Experiment.] That will go on for some time before it comes back to zero. I wish to charge the human body, and keep it charged for some time. I will substitute the real man for the schema. Here again I shall not be able to do the experiment immediately. The resistance of the real man is somewhat less, but not materially less, than that of the schema. Whilst that is going on I will go on with the measuring experiment which I mentioned before, and which I owe to the kindness of Mr. Lant Carpenter and his assistant, Mr. Wilkinson. Some of the resistance determinations I gave at the last lecture, if you recollect. The diagram is up there, as I thought we might be referring to it again [indicating diagram]. One cell of 2 ohms was put on for four minutes, and the actual resistance of the patient at the end of the first minute was 1194. It rose by polarisation to 1230 ohms. The current passing was ·0016 ampere. The resistance then remained steady, and stood at 1155, as you see there. Then comes the test for capacity, and it was by these tests that I came finally to the conclusion that capacity was not the right name for this action, although something of the nature of piling up of the current, which is now better called self-induction, most undoubtedly does occur. In the first experiment two cells were kept on for four minutes, and all the details of the experiment are very beautifully given [indicating diagram]. There was a shunt of one ohm. The discharge at the end of the time was 185 divisions of the same shunt. Then the leakage was measured. The leakage between my two baths I could not prevent, although they were on an insulating material. There was a leakage equal to 142 divisions. Now, this deflection is only ·043 per cent. of the test, and may be altogether neglected. I then tried whether the baths on the floor took any charge themselves. The deflection was 268 divisions, but this is only ·025 per cent. I think we may say that both these tests came out in favour of the accuracy of the observation. Ultimately the resistance then comes out to what I have there, 1,155 ohms. That was with a current of ·00346 ampere. I will now pass on to what is more easy to follow. We then discharged the patient himself, with no battering circuit. It was through the same galvanometer and under the same conditions exactly, and we got a current from him equal to 60 microamperes, and three minutes after that it had fallen to 48·7, and two minutes after that it had fallen to 45. Now, I thought that so important that I have enlarged the curve and given it you here on two diagrams. [Indicating.] Here is the first, and here are the minutes on the horizontal line, and here is the fall of the current. It is very nearly a straight line, and you will see that it discharges itself very much after the fashion of a secondary battery. I was not even satisfied with that, and I gave my two kind assistants a little more trouble. I asked that the curve should be plotted out in which the original throw, the condenser action, should be blended with a careful appreciation of the charging and discharging current, and I have no hesitation in saying that it is a very beautiful curve indeed. It opens a grand field for electrical inquiry as applied to the animal body, and more especially the human body. It hardly needs explanation. Here is the charging current. At the point B [indicated] a discharge takes place, and up goes the galvanometer to C, and then it comes down to this point, and this is carried on for ten minutes, and the fall of the current is very regular and very slow, as you perceive. Before the galvanometer came back to zero would certainly be several hours. This is only from 2 volts current. We then went on to see how much of this throw would occur with the needle swinging under its own inertia. Another test was therefore taken under the same conditions, using an inert instead of a polarisable resistance—using an ordinary resistance instead of the man (the same patient, I may say, was used in all these observations), and the needle did not reach its previous position and did not fly out so far. Therefore the difference between these two must absolutely be the measure of the difference of the polarisation which took place. There is the test. [Indicating it on the diagram.] That is a small quantity. But the electromotive force was very small indeed, only just competent to combat the counter electromotive force. Water can hardly be decomposed with a single cell, and we were only using a single bichromate cell. Yet we got that very decided difference, which I think completely proves what I have been contending. The result of all this is that as regards the electrostatic capacity of the body it is very difficult to separate polarisation from capacity; and perhaps it is wiser not to say that it is capacity, but that there is a self-induction. Now, after the 10 minutes I think I can discharge my human condenser directly. [Experiment.] I am happy to say it is quite visible.

This has a very important physiological bearing, and the bearing is on electrotonus. I confess I have always been sceptical as to the reality of electrotonus. Every writer seems to inveigh against its inconstancy, and the difficulty of getting results, not to say the reliability of the results when they are obtained. Here, for instance, is the last work of Rosenthal, who says: "It sometimes goes one way and sometimes the other, and there have been great disputes as to it." I will not read the whole passage, because time will not allow of it. Then here is an excellent though rather bulky volume, containing the remarks of Drs. Waller and de Watteville. It mentions various authorities, and goes on to say: "In a determination on the ulna nerve, Eulenburg and other observers simultaneously came to opposite conclusions. He attributes the inconstancy of the results to the inconstancy of the nervous matter, a view which was followed by many physiologists. Every one of them assumes something, and all their results are heterogenous to the last degree; there is obviously something wrong somewhere. I have felt that for a considerable time, but I hope we are on the way now to see what is wrong. I do not in the least deny that such an action as electrotonus does take place. But too much stress has been laid upon physiological points, and the investigation has been carried on without looking to see that the physical agent is constant in all conditions, and acting under the same circumstances. For instance, Rosenthal lays such great stress in the very first quotation on anode and cathode, though anode and cathode are purely fictitious terms. He considers that the current goes from the anode to the cathode, but we have no means of knowing that it does. It may go the other way. We call the one plus and the other minus, and we have to assume the upward and downward movement or the influence of the two poles. This is the first assumption. But we do know something else about the two terminals by electro-chemistry. We know that at the plus terminal in an electro depositing apparatus oxydation takes place, and at the minus terminal hydrogen comes off. We know in this way that if we are not working at the deposition of metal, but take a different body, we get a secondary battery, and I have not the smallest doubt from these observations that the effects are effects of electro-chemical decomposition. No doubt that chemical decomposition will transmit excitement along the nerve, and make the muscle contract, and the inconstant results obtained are due to chemical decomposition of the nature of polarisation. Now, we are always finding in books such phrases as these—which are thoroughly unscientific—"when the currents are weak the neutral point lies near anode, when they are strong it is situated nearer the cathode. When the currents are of a certain medium strength it remains at an intermediate position—that is, exactly midway." Now, what is medium strength? I want it in amperes—in some physical measure. You do not get it anywhere. But I do know that the medium strength, where the balance is maintained, is a strength which exactly balances the counter electromotive force of the body, and that is somewhere below a volt. When you get up to two volts, you see that the electro-decomposition is clear enough. The certain medium strength which ought to be measured, and must be measured, is the balancing electromotive force of the body. And the currents that have been used, as a rule, principally by Du Bois Reymond, are infinitely too strong for accurate determinations. He talks of using 11 or 12 Grove cells, but I should be very sorry to pass them through a patient without great precautions. An accident might occur from that. In fact, in the case of the Count du Moncel, an accident did occur, and he used 8 Daniels, which is 8 volts, whereas 11 or 12 Groves would be about 24. I think I ought to say, as I do not want to be misrepresenting Rosenthal, who is a very able man, and one of the great electricians of the German school, that he frankly makes the admission that the currents are inconstant. "If," he says, "a continuous current is passed through a nerve, and is alternately closed and opened, the excitement appears to grow irregular, sometimes at the closing and sometimes at the opening of the current, and occasionally even at both." There is another error which runs through the physiological observations, and that is what is called the tetanizing key of Du Bois Reymond. It is a short circuiting apparatus, as the electricians call it. It puts a good conductor in the course of the current, and is supposed by physiologists entirely to cut off the electrical agency from the large loop conductor outside, but it does nothing of the sort. The law of double circuits is that the currents are divided in the inverse proportion of their resistance, but there is no law that the resistance in a large circuit is completely stopped by Du Bois Reymond's key. Du Bois Reymond's tetanizing key has been another source of inconstant effects. Rosenthal, who was a distinguished pupil of Du Bois Reymond, says, speaking of the key: "The lever is made short and thick, and being made with a short, thick piece of brass which offers hardly any resistance, while the muscle offers great resistance, the current nearly all passes through the key." This is not a scientific or satisfactory arrangement. It should be none or all. When

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we add to a constant current the induction coil, the problem becomes infinitely more complicated; and when we do as some observers have done—when we add a continuous current and an induced current to one another, to the same stream—I am quite certain that the problem is physically past solution. They have done more than that. There are induction coils now made in which the current of the primary is transmitted through the secondary complex circuit in that way, and then the continuous is added on, all unmeasured, piled on the top of one another, and no wonder the effects are inconstant. One does not know which way the current will run, and which predominates over the other. Next comes a most distinct false assumption, which I hope to prove to you at the next lecture, and here I may be doing Dr. Waller and de Watteville an injustice if I did not read the following passage. I will not read, however, the whole. He speaks of using a constant current and an induced current as the mode of producing electrotonus. He says, respecting the testing current, whether galvanic or induced: "Since the laws of diffusion are the same for both." I do not believe the laws of diffusion are the same for both, and the fact upon which I found that belief I shall demonstrate to you at the next lecture, for whereas my patient gives 1,100 ohms resistance to the constant current, even when corrected for polarisation, to the induced current he only gave half that. This is a most important fact which I *lately* discovered. An induction current will pass through the body and give only a resistance of about ½ to ⅔ under a constant current, even when corrected in every way for polarisation. Here is a case where it is curious to observe what happened. The patient gave a resistance corrected by Mance's method of 1150—it really came out a little below that, but we will call it 1,150. With an interrupted current he gave a resistance of 575, the exact figures being 1,141 against 575. It is very nearly 2 to 1. Therefore the laws of diffusion, I say with confidence, are not the same for the two. What may be the cause of the difference I do not know that I am quite prepared to say at length. But this fact must have a physical origin. I will take that up more largely at the next lecture. I explained at the last lecture that we have in the telephone an instrument by which we can reproduce physically many forms of testing machinery which were formerly of a physiological character, and the observation is so interesting that I shall ask you to allow me to go a little more into it to-day. If you will kindly take down the telephones I will at once proceed with the experiment. I have an interrupter here with which I can make and break a current at different paces; and here you will be able to discover that the result is not only audible, but if you listen carefully you will hear that the ticks given by one and the other act are considerably different. [Experiment.] There comes a period if I slide the sledge along when the tick of making contact disappears. It goes gradually down and fades out. The one tick fades away and leaves the other. Now, this is exactly what has been shewn in galvanoscopic frogs, as a means, as it is said, of getting pure excitements. But it is nothing more nor less than what is due to that physical action. This can be done without a frog, at a distance, with a telephone replacing the frog. Therefore, I hope I have carried conviction to you. To me it seems very plain that what Dr. Walker admits when he says that we are dealing with physiological signs alone has been a somewhat dangerous course of action, and that that error has arisen from not measuring our instruments more carefully, and that the prospects of advance in this direction will be by building up from the foundations; by ascertaining what is the force we are using, and how it acts; and then on the top of that to put the physiological determinations. Many of the observations that have been made—and they are very exhaustive (even Du Bois Reymond's volumes alone are the work of a lifetime)—are very interesting, if not convincing. There is another point which has stood in the way of accuracy, and that, I may note, is that over-sensitive galvanometers have been employed. The delicate Thomson galvanometer—beautiful instrument as it is—is so very sensitive that it requires to be somewhat heavily shunted, or you can hardly handle it. The same thing applies to the galvanoscopic frog. We have no means of calculating the accuracy of that. Probably no two prepared frogs have exactly the same power, neither do I see any way of obtaining it. It used to be said we moved up from electroscopes to electrometers when Sir Wm. Thomson discovered the method of measuring in real units. We want to move from galvanoscopes and from physiological shades of action to those which will measure resistance with accuracy. I have great hopes that the telephone will be of service in this way. The telephone is an exceedingly delicate instrument. It is so very delicate that it almost has the fault of delicacy; but we have the power of improving it, and I will show you at the next lecture that we can use it so that it will take the place of a galvanometer in the ordinary Wheatstone bridge current, if you will only interrupt the current; but not in the way in which it is interrupted in an induction coil, but by a small chronometer. Then by our interruption current the telephone gives a tick and it can be silenced when the two resistances are equal, as in the usual case of the Wheatstone bridge, provided however that the two currents are equal in self-induction. The beautiful instrument of Prof. Hughes not only measures by means of the Wheatstone bridge, but using the telephone as a galvanometer measures resistance and also the self-induction. I find that these physiological substances exhibit a very considerable amount of self-induction. There is even a better plan suggested by Lord Rayleigh, although it was originally theoretically produced by Clerk Maxwell—that is, coiling two wires side by side, and making one of them a closed circuit, pass the current through the other, and that I expect will be the way in which we shall be able to measure the self-induction of differences of compact bodies like the human body. In the meantime, I feel sure that much that has hitherto been done will prove to be purely physical, that the investigation, although laborious, has been greatly misunderstood, and, in some cases, ingeniously misinterpreted.

PROF. FORBES' CANTOR LECTURES.

LECTURE I.—*(Concluded from page 441.)*

Now, when I have been showing you these phenomena of attraction and repulsion, I would ask you whether you are fully satisfied with the old view which used to be held, according to which electricity is a fluid material which settles upon the surface of electrified bodies, and, acting across the intervening medium, produces by a kind of action at a distance attraction and repulsion upon other bodies. It seems inconceivable to me that these actions can take place at a distance without the intervention of some medium between the mutually acting bodies. The existence of such an intervening medium seems to be essential to a conception, which we may eventually arrive at, as to the action of electricity and the action of gravitation. Such a medium we are almost certain does exist. The theory of light has almost conclusively proved to us that there is such a medium pervading all space. Whether or not that is the medium which is producing electrical phenomena and gravitational phenomena I will not venture to assert. But Newton asserted his incapability of realising the action of force at a distance, and every philosopher I think must feel the same instinctive aversion to the notion of force acting at a distance without some intervening medium. I have spoken about the Leyden jar. A Leyden jar consists of nothing more nor less than two conducting substances separated by an insulating material such as glass. It is made in the form of a jar, because there is less chance of the electricity passing from the outside coating or conductor to the inner coating or conductor. It was first discovered by a glass vessel being filled with water, which a philosopher was trying to electrify. He was holding it on the outside with his hands, and by making a contact with the inside he was actually getting that shock which you saw me get by connecting it with the outer coatings. Communication is of course taking place between these two coatings, and the nearer the coatings are together the greater is the communication. By having a thin piece of glass, we are able to have a powerful communication; but we must not make our glass too thin, because there is a certain strength beyond which the glass does not go, and if we exert it too far we pierce the glass and fracture it. Now, you will notice that this introduces the notion of a strained glass—that between the two coatings there is a strain between the two surfaces, and this is a notion which was thought of by Faraday, and which he developed into the conception as to the nature of induction which is universally held by electricians. He supposed that in these phenomena of attraction and repulsion the whole action is taking place in the medium between the two conductors. He showed it was impossible to give an absolute charge of electricity to one substance without giving an equal and positive charge to another substance; and there must be a course of induction between the two electrified bodies which are separated by an insulating medium, such as the air. I will make an experiment with a Leyden jar to show that to you. Here I have a Leyden jar which has the parts capable of being separated. Faraday's view was that the conductors are not electrified, that it is wrong to speak about the conductors being electrified, that the whole of the phenomena is in the glass, and that it is the straining medium by this new inductive action which produces the whole phenomena of electricity. I will now show you that Faraday's view was, so far, correct—that the charge undoubtedly does exist in the glass, and not in the electrified body. [Experiment.] I had discharged the outside and I had discharged the inside; I had left the glass strained, as Faraday said it was strained, and having put its inner and outer coatings on once more I was able to get a spark from the glass which had continued to possess its strain. Now, if it is a case of strain, a material which is once strained takes a little time to get rid of its strain, and here is an experiment which will show you that this is the case. You saw I had a spark there; I had discharged this machine, and yet you saw I got a spark. I will get up excitement in this machine, and then I will discharge it. The poles of this machine are connected with Leyden jars. I will discharge the Leyden jars so that no more charge exists. They are discharged. I have connected them. But the glass in these Leyden jars is still twisted, and is gradually untwisting itself, and as it untwists itself it develops the electrical condition; and now I shall be able to get another discharge. [A very feeble spark was shown.] Sometimes I can get a considerable number of discharges in that way. I will show you that by a piece of material which is called dermatite. I will charge myself with this, and I will show you what a long time it takes to get rid of its electricity. Now I am pretty well charged. [To his assistant.] If you will hold up your finger I will give you a charge. [Experiment.] It is not a very distinct spark. There is another. [Mr. Davenport (the assistant) was able to take a third spark—a fourth, a fifth, a sixth, a seventh, an eighth, and a ninth. He was able to feel the ninth.] If it had not been that that material dermatite took a long time to get rid of its strain the first discharge would have completely discharged the electricity in my body; but because of the peculiar construction of the material, it takes a long time to get rid of the strain, and so the successive discharges are shown, as the strain is gradually going off. I will mention a striking experiment to show that this induction is a state of strain, which Dr. Hopkinson did many years ago—how to give a residual discharge from a Leyden jar. [By a delicate measuring instrument he showed the rate at which the strained glass was giving it off—the rate at which the difference of potential was diminishing between the inside and outside of the Leyden jar; and he tapped the jar mechanically in this way. [Shown.] We know that tapping it would make it get rid of its strain, and in doing so, while he was measuring the electricity from the Leyden jar, he trebled the quantity which was being given off by tapping it. I think this is almost a conclusive proof that the increase which takes place is really a condition of strain. This was

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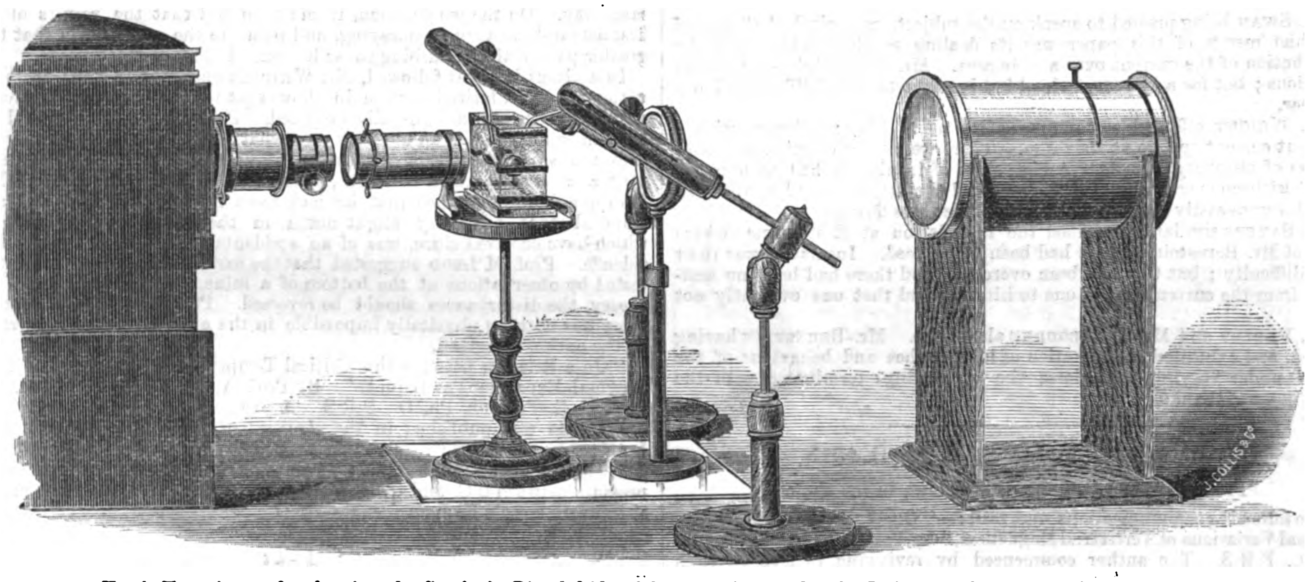
really the theory enunciated by Faraday. This was the theory worked out more thoroughly by Clerk Maxwell, and he showed that if we supposed the medium air, or whatever it is, to be exerting a tension where tension has taken place, and exerting pressure at right angles to that, all the phenomena of electricity and equilibrium can be thoroughly explained in that way. It would therefore be necessary to prove not only that there is a state of strain, but also that the direction of the strain is as predicted. This is a brilliant experiment, which was accomplished by Dr. Kerr, of the Free College of Glasgow. I am afraid, however, it is hopeless of me to show it to you. It is an experiment that has only been once or twice completed It is so very important, however, to show you an experiment which has actually proved to us that the theory of Faraday as worked out by Clerk Maxwell is true, namely, that the strain of an insulating medium is in a certain direction, that I did want to show it to you although it is somewhat difficult to do it. I will show you the form of apparatus at any rate (Fig. 1), and then I will do my best to show the result which Dr. Kerr got. You will pardon me if I fail in doing it. At the same time I will take this opportunity of showing you more powerful effects with Mr. Wimshurst's machine when it is exerted to its utmost capacity. Here is, meantime, an electric lamp, by means of which I shall show a beam on the screen on the wall there. I will throw a small image on the screen. I have an instrument here which is called Nichols' prism, through which the light has to pass, and I have to thank Dr. De La Rue for enabling me to show this experiment. This is Nichols' prism, which does not let any rays of light vibrating in the direction I have spoken of pass through it, and, therefore, when we have arranged Nichols' prism in that way, the one cuts off the light from the other, and we shall see no light on the screen. I now place a vessel, containing bisulphide of carbon, in a focus of the lens between the two Nichols prisms. I have two glass tubes with bulbs on their ends filled with mercury, and I have wires passed from the mercury and passed to wires which go to the conductors of the large Wimshurst machine. At this moment Nichols' prisms arranged to produce darkness. I twist one round its axis so, and a bright light is seen. Now, by twisting this Nichols prism I can produce complete darkness. Now, I shall be able to show you the effect of introducing into this a beam of light. If I introduce into this position any transparent substance in a state of strain it has the power of restoring the light in that central part. Light can be restored in the central part if I had a body in a state of strain. The brilliant experiment done by Dr. Kerr was to charge powerfully with a difference of potential of electricity, and then he was able finally to see light on the screen. There is far too much stray light about. I am afraid it will require the best of eyesight to see it. But there is nothing like making the attempt.

He concluded by showing the large quantity of electricity generated by Mr. Wimshurst's machine when it was exerted to its full capacity.



Kerr's Experiment for showing the Strain in Bi-sulphide of Carbon when under the Influence of Electrostatic Induction.

THE SOCIETY OF TELEGRAPH-ENGINEERS AND ELECTRICIANS.

At the meeting of this Society on Thursday, the 8th inst., Prof. HUGHES, president, in the chair, the discussion was renewed on Mr. BERNSTEIN'S paper, read at the preceding meeting, on "Electric Lighting by Glow Lamps of Low Resistance." A group of these lamps constructed on Mr. Bernstein's principles, and fitted each with one of his switches, was kept alight during the evening by a Thomson-Houston machine.

Dr. FLEMING offered some criticisms on the paper chiefly relating to the misuse of the word "strain," and to the relative values of thick and thin filaments. With regard to the latter, he was of opinion that the life of the lamp depended on the homogeneity and uniformity of the carbon, not upon its thickness. As to the comparative danger of the two systems of high and low tension currents, he thought them about equal. In the one case insurance would have to be effected against fire, and in the other on life, only in the latter unfortunately compensation would not restore the loss. The chief difficulties in this country arose in obtaining perfect insulation underground, difficulties which, with their overhead wires, were more easily overcome in the United States.

Mr. MORDEY drew attention to the fact that at Brighton, Eastbourne, and other places, installations of glow lamps had been carried out, and were being successfully conducted on the series system. The lamps used, he believed, were usually of ordinary construction, arranged in multiple series, but he understood that, although lamps of such low resistance as Mr. Bernstein had been successful in constructing had not been used, some lamps of comparatively low resistance, made by Mr. Swinburne, had been tried, and, he believed, with success. These lamps took 3·3 amperes, and were of small candle-power. Groups of three of them were inserted in the circuits of the Brush dynamos. Mr. Wright, of Brighton, Mr. Sayers, who carried out the work at Eastbourne, and Mr. Swinburne were present, and he hoped they would give some account of their experience. He thought the author unnecessarily confined himself to a recommendation of lamps arranged in single series. While these would be useful where it was desired to turn lamps on or off singly, it would often be convenient to use groups of lamps in multiple series. He shared the common belief that it was of the utmost importance that lamps should have long lives. He held this opinion in spite of Mr. Preece's statement that it would be better to work lamps at a higher efficiency and with a shorter life than was usual; and also in spite of Prof. Ayrton's remark that the cost of lamp renewals was a very small item in the total expenses. Cost was not the only consideration. There were serious objections to short-lived lamps, as, for instance, the inconvenience and danger of a room or railway carriage being placed in sudden darkness. If lamps of high efficiency were used, he thought it would be an absolute necessity to provide duplicate lamps or filaments which could be automatically thrown into circuit in the event of breakage. Although in favour of series working he pointed out that this system must of necessity give shorter life of lamps than the parallel system, because in the latter when lamps became old the increase in the resistance enabled them to exercise a considerable preservative power—they then took less current; while in the series system, as they were always traversed by the same current, disintegration took place with continually increasing effect, and they approached their death very quickly, and not with diminished candle-power, as was the case with the parallel lamps. He supported the author's assumption of the possibility of maintaining the current constant. Constant current was a physical possibility; constant difference of potential in any distribution system was not. Mr. Drake had stated that it was difficult to keep the current constant, and that the Brush regulator for this purpose would not act; but he believed that Mr. Sayers had been quite successful in using this apparatus at Eastbourne, even for glow lamps, and he knew that it could be relied on. He could never understand the position taken by those who so strongly opposed high tension working, the advantages of which were enormous. Mr. Bernstein had done a great service in drawing attention at this time to this question, when, thanks to the teachings of Prof. Forbes and others, electrical engineers were in a position to consider such questions on their merits. He thought the constant-current method had been too much neglected, although he did not suppose that in ships,

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and generally in compact installations, it would ever be used, as even in the cost of conductors it would have little or no advantage, a comparatively heavy wire having to be taken to each lamp; but for long lines the reverse was the case. He thought the author would find that a No. 6 wire was needlessly large for true economy in most cases, but it would be interesting to see what could be done with such a wire. With ten amperes passing through it, the density of current was only 300 amperes per square inch. The loss would be 14 volts per mile, or equivalent to 2·3, 60-watt lamps. This was only a loss equal to a 60-watt lamps for every 750 yards. He thought dynamos giving 3,000 volts could easily be used. The largest Brush dynamo gave nearly that E.M.F., and worked quite well. Such a machine would send 10 amperes through 215 miles of No. 6. wire. For every 750 yards taken off, a 60-watt lamp could be put in. Thus, on a circuit of twenty miles 450 lamps could be used, and even with this long line the conductor efficiency would be 90 per cent. He might put it in another way, as an illustration, and say that an arc lamp in a lighthouse 210 miles from shore could be worked by such a machine if a cable could be laid with sufficiently good insulation, using an earth return. He thought the objection to high tension on account of the danger was not well grounded; the danger was exaggerated. Although for four or five years he had been engaged daily in working with high-tension dynamos in the works of the Brush Corporation, there had never been a case of personal injury or any accident from an electrical machine, although in the same works there had been several accidents from non-electrical machinery. If the opponents of high-tension applied their extreme caution to other things, and carried their case, railways would disappear, and cabs and omnibuses would become a thing of the past. The world would sink to a state of almost absolute zero, when there would be very little motion, and that motion very slow. With regard to automatic cut-outs, he thought electro-magnetic ones were best. Prof. Forbes and others had objected to them on account of the energy absorbed. This was simply a question of construction—the energy could be reduced to almost any extent. In the cut-out of the Brush lamp, for instance, the energy absorbed was only five-eighths of a watt.

Mr. SWAN being pressed to speak on the subject, remarked that one of the chief merits of this paper was its dealing so thoroughly with the distribution of the current over a wide area. Mr. Bernstein's switch was ingenious; but for a system of this kind it ought to be infallible, and not too dear.

Mr. WRIGHT afforded some information as to his experiences with a constant current system at Brighton. There were three circuits, covering an area of about eight miles. A high state of insulation had been maintained with no extraordinary difficulty, and the detection and localisation of faults were easily effected while the current was flowing.

Mr. SAYERS similarly described the installation at Eastbourne, where some of Mr. Bernstein's lamps had been introduced. Insulation was their chief difficulty; but this had been overcome, and there had been no accidents from the current except one to himself, and that one evidently not fatal.

Mr. VARLEY and Mr. SWINBOURNE also spoke. Mr. BERNSTEIN having replied, and exhibited the operation of his switches and behaviour of the lamps under varying conditions, the proceedings terminated with the usual votes of thanks.

PHYSICAL SOCIETY.—April 10th.

Prof. BALFOUR STEWART, President, in the chair.

The following communications were read:—"On the Cause of the Solar-Diurnal Variations of Terrestrial Magnetism," by Prof. BALFOUR STEWART, LL.D., F.R.S. The author commenced by reviewing various theories that have been advanced to account for the solar-diurnal inequalities of terrestrial magnetism. That they can be due to the direct magnetic action of the sun is highly improbable, since terrestrial analogies would lead us to infer that matter at the temperature of the sun is quite incapable of possessing magnetic properties, and also from the fact that changes in the range of the daily variation lag behind corresponding solar changes in point of time. The hypothesis of Faraday that the observed variations are the result of the displacement of the magnetic lines of force due to the varying temperature, and consequently varying magnetic permeability, of the atmospheric oxygen, is disproved by the fact that there is no agreement between the chief magnetic variations and those of the temperature of the great mass of the atmosphere, though it is certain that there must be some effect due to this. The earth current hypothesis is quite unable to explain one of the chief characteristics of these variations—that they are half as great again at periods of maximum as at those of minimum sun-spot frequency. Sir George Airey has, moreover, been unable to detect any resemblance in form between the regular diurnal progress of the magnet and that of earth currents. We seem, therefore, compelled to seek for the cause of the variations in the upper atmospheric regions, and we cannot imagine such a cause to exist in any other form than that of a system of electrical currents. That currents may, and actually do, exist at great heights is shown by the Aurora, which is unquestionably an electric current, and manifests a close connection with the phenomena of terrestrial magnetism. The great increase of magnetic variation at epochs of maximum sun-spot frequency can also be accounted for on this supposition. Prof. Stokes has remarked that an increase in the radiating power of the sun would probably imply not only an increase in general radiation, but a special and predominant increase in such actinic rays as are probably absorbed in the upper regions of the earth's atmosphere. These regions will therefore greedily absorb the new rays, their temperature will rise, and, as is known to be the case for gases, the electrical conductivity will be increased. Thus, even if we imagine the general atmospheric current to remain constant, a greater proportion of it would be thrown at such times into those heated portions which had become good conductors, but it is also probable that the current itself would be increased. Assuming the existence of currents at great altitudes, the regularity and general characteristics of the diurnal variations would seem to point to a direct magnetic action of the currents rather than to any general induced change in the magnetic system of the earth, which, to produce the observed results, would have to be of a very artificial character. The diurnal variation of the declination, attaining a westerly maximum at 2 p.m., north of the equator, and an easterly maximum at the same time south of it, would suggest the existence of currents flowing northward and southward from the equator to the poles, obtaining a maximum in each hemisphere about two hours after the sun had passed the meridian. To supply this flow we should probably have to assume the existence of vertical currents ascending from the equatorial regions of the earth. At this point Dr. Schuster has endeavoured to apply mathematical analysis to the subject From the recorded observations at Greenwich, Lisbon, Hobarton, St. Helena, and the Cape, he had shown that the work done by a magnetic pole describing a closed path in a horizontal plane at those places is equal to the work done upon it, and consequently no part of the ascending current can be enclosed by the path. Hence the potential at those places obeys the law expressed by the equation

$$\frac{d^2 V}{d x^2}+\frac{d^2 V}{d y^2}+\frac{d^2 V}{d z^2}=0.$$

From this, Dr. Schuster has deduced two possible expressions for the potential, one referring to a system of currents above our heads, and the other to one beneath our feet. From the first of these expressions it follows that for latitudes greater than 45° the maximum of horizontal force should coincide with the minimum of vertical force, and *vice versâ*, and this is actually the case at Greenwich; while the opposite should hold if the influencing system were beneath us. For latitudes below 45° the reverse of the above should be the case, and the observations at Bombay, though less decided than those at Greenwich, would seem to point the same way. On the whole, then, it must be said that the results of the first attempt are very encouraging, and point to the supposition that the greater part of the disturbing cause lies outside the earth's surface.

In a discussion that followed, Mr. WHIPPLE remarked that recent observations in high latitudes seem to show that the Aurora is not always at such a great height as is usually supposed. Prof. A. W. Rücker cited the well-known case when an observer saw what appeared to be a meteor fall into the sun, while, simultaneously, or nearly so, there was recorded a magnetic disturbance on the earth, as showing a direct solar action. Mr. Whipple, however, stated that he had recently examined this point, and believed that the very slight notch in the record, many similar to which have occurred since, was of an accidental nature, and a mere coincidence. Prof. M'LEOD suggested that the earth current theory might be tested by observations at the bottom of a mine, where, according to the theory, the disturbances should be reversed. Prof. ADAMS believed that there was nothing physically impossible in the existence of such currents as the author imagined.

"On a Relation between the Critical Temperatures of Bodies and their Thermal Expansions as Liquids." By Prof. A. W. RUCKER, F.R.S., and Prof. T. E. THORPE, Ph. D., F.R.S. A paper by the authors bearing the above title was published in the *Journal* of the Chemical Society of London for April, 1884. The substance of the paper was as follows:—Prof. Mendelejeff has shown that the expansion of liquids under constant pressure between 0°C. and their boiling points may be expressed by means of the very simple formula

$$V_t = \frac{1}{1-kt}$$

V_t being the volume at t°C (that at 0° being unity) and k a quantity which differs for different substances, but which may for any one substance be considered invariable between 0°C and the neighbourhood of the boiling point. From this law the authors have obtained, as a deduction, the following expression for the critical temperature (T) of any liquid

$$T_c = \frac{TV_t - 273}{a(V_t - 1)}$$

where V is the volume at t°C., T the absolute temperature, and a a quantity which is very nearly constant for all substances, and which was shown to be very nearly 2.

In a recent paper (*Ann. Ch. Ph*, March, 1886), MM. A. Bartoli and E. Stracciati have discussed both of these formulæ, and have applied them to cases in a manner never intended by the authors. They have expanded Mendelejeff's formula into the series

$$V = 1 + kt + k^2t^2 + k^3t^3 \ \ldots\ldots$$

which is a geometrical progression, and they have objected to it that the results of Piere, Kopp, Hirn, Thorpe, &c., do not give for the coefficients of t, t^2, t^3 quantities in geometrical progression. The results of these observers are given in the usual form

$$V = 1 + at + bt^2 + ct^3 + \ \ldots$$

but owing to unavoidable errors of experiment the constants c, d_8, of different observers differ very largely, and Mendelejeff's simple expression gives the results of all quite as accurately as the facts will allow. MM. Bartoli and Stracciati have then criticised the expression given by the authors, and have applied it to determine the critical temperature of water from its expansion to 200°C., whereas the original expression is only given as applicable as far as the boiling point. They have further recorded a number of critical temperatures calculated by the formula to tenths of a degree, for which the constant a would require to be known to ·025 per cent., whereas there is no reason for supposing it known to within 1 per cent. or more.

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COMPANIES' MEETINGS & REPORTS.

The Indo-European Telegraph Company (Limited).

The nineteenth ordinary general meeting of this Company was held on Wednesday, at the Cannon-street Hotel, Colonel James Holland in the chair.

Mr. W. ANDREWS (the Managing Director) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN said: I have now to move that the report and statement of accounts be received and adopted.

Mr. H. WEAVER: I beg to second that.

The CHAIRMAN: That has been moved and seconded, but before putting it to the meeting I should wish to make a few remarks, which, I hope, will meet with your approval. It is, as you may easily suppose, gentlemen, a very satisfactory thing for us to be able to submit to a meeting a report so satisfactory—I think I may say that of its features—as the one I hold in my hand. It shows an increase of upwards of £18,000 over the report of last year, which in itself was not a bad one. The balance sheet seems to me to call for very little remark, unless there is any point which the gentlemen present wish to refer to. There is one item, however, on which I should like to make a passing remark, and that is the very small amount of the law charges—some £40 for the year. That, I think, gentlemen, is very satisfactory to us; I think it is probably hardly so satisfactory to my excellent friend, Mr. Bristow, our worthy solicitor, who has conducted our business in so satisfactory a manner that the law charges have been so very small indeed. Indeed, I can say this—Mr. Bristow has for some years been our legal representative, and on all occasions we have found whatever he has done has been done most satisfactorily. He has always, when necessary to apply to counsel, taken care to employ the most judicious gentlemen, and one of the results of of the action of our solicitor (I do not say all) has been that we are very clear of law charges. I really cannot think there is a higher praise to be awarded to any firm of solicitors, and I am very glad to see Mr. Bristow is present. Well, gentlemen, although we have made a sum of upwards of £18,000 over the return of last year, the actual expenditure on every account is somewhat less than that of some years. That I look upon as one very satisfactory feature. There is an increase of about £1,600, in order to enable us to work the much greater traffic we have had; but the increase is more than negatived by the improvement in the accounts for the maintenance. Now, that I look upon as a very satisfactory point indeed, that our maintenance year after year, for some time, has been improving. Much has been done to keep it up to a high state of efficiency, and I think it is next to impossible that anything could be better than the maintenance of our line at the present time. Notwithstanding that great improvement, the cost for the year is some £1,700 odd less than that of the preceding year, and if anything could add to the deep debt of gratitude that you all owe to my worthy friend on my right, Mr. Andrews, I think that that fact alone will come to your hearts, and I think a shareholder's heart is generally said to reside in his breeches pocket. Another reason why this satisfactory state of things has been brought about, after according all due credit to our manager, has been that we have taken care from the beginning never to increase our capital charges. Whatever expenditure has been incurred has been from revenue. From day to day the expenses are paid up and we have nothing lurking behind to give us the least degree of apprehension. We find all our costs paid as they are incurred, and the capital in no respect watered. We hope that we shall be able to carry on the system to the end, and I see no reason so long as we carry on the system and largely increase our reserve fund but that the same satisfactory progress may be relied on year after year. I have said before that the line is in a most efficient state, and you must naturally infer from that circumstance that we must go on realising the large profit that we have done for the present year; but, gentlemen, I am sorry I must put a damper upon any extravagant hopes that are raised in this direction, because in the first place, if you look to paragraph 8 of our report, you will find that the profit is exceptional. We state here "The large augmentation of revenue is quite exceptional, and is owing to the total interruption of the Eastern Company's lines for some three weeks, the disturbances in Burmah, and the Afghan Frontier question, and it is satisfactory that the £18,046 of additional revenue has only occasioned an increased expenditure on commercial account of £1,637." So, gentlemen, you must not expect this kind of revenue every year. War and political disturbance, which in this particular year has proved so exceptionally beneficial to us, is like a two-edge sword, it cuts both ways. We have had the sad experience of what war can do, to our great discomfort and annoyance, in the war between Russia and Turkey, in which some sixty miles of our line were destroyed and our revenue totally put a stop to for a considerable period; so that, although war sometimes, as in the past year, has been beneficial to us by the great amount of political intelligence that it is necessary to convey over our lines, yet it may be just as damaging on the other hand; and, therefore, we must not reckon upon war being a friend to us. Our truest friend is commercial prosperity. That, unhappily, has been and is at a very low ebb, but all we can do is to hope that things may mend. We trust that they may, because that is the real substantial prosperity that will last us for a considerable period. Well, then, in order that the prosperity may be beneficial to us, it is necessary that we should do our utmost to make friends of the commercial public. There are two modes of doing that. The first is to see that the line works in a most efficient manner. It is my belief, from close inspection of the matter, that it is impossible that the line can work better than it does at present, and I have stated to you to whom the credit is mainly due. The merchants, no doubt, are very well satisfied; in fact, I know they are, and must be, satisfied with the way the work is done. But they will also very likely say, "But, gentlemen, you charge a heavy price for your work; the work is very good, but the price is very costly." It is true it is costly, but the maintenance of a line in a thoroughly efficient state to India must at all times be a costly matter. We have, however, in consequence of the prosperity that we now actually enjoy, and in the hope that trade will improve, at the last quinquennial conference of different telegraph authorities of Europe proposed that the 4s. 7d. rate per word should be reduced. It was, after considerable discussion on all parts, in which our general manager, assisted by our able accountant, Mr. Mall, took a leading part, and under the presidency of a very distinguished statesman, Dr. von Stephan, the German Minister of Postal Telegraphs, and aided also by the good offices of a very illustrious member of a very illustrious house, Dr. Werner Siemens, himself a German resident at Berlin, who gave his best assistance to our endeavours, and with all these gentlemen present, and the Indian Government being anxious also to see such reduction as could fairly be made, we have reduced the rate from 1st July next to 4s. from 4s. 7d. At the same time considerable reductions have been made in the Trans-Indian telegraph to China, Malacca, and very many parts beyond India—reductions varying from 1s. to 1s. 6d. a word, all of which I see have been published, and, therefore, you will hardly desire me to read them over, although I have the printed list before me. Well, gentlemen, I have brought in the reduction of the tariff as one of the arguments to show that you must not expect an overwhelming profit year by year, because you must bear in mind that every reduction made on the tariff tells upon the gross receipts that the gross profits and the net profits are two very different things. The fact is the loss of 7d. to us is equal to about double the loss, being on the gross profits, whereas we have to pay you out of the net profits. In addition to this reduction of rates we are now considering with the Post Office and with various other companies a very considerable reduction in the press rates. A previous reduction of the press rates was originally proposed by our Company, and it was carried out in the first instance by the Indian authorities, who are, as you are aware, partners with us in this concern. It is a very satisfactory partnership in one respect, because the influence of this powerful Government — the Indian Government—shields us to a great extent from unreasonable competition, on one condition. That condition is that our line works in the most perfect state that is possible. The moment we let the maintenance fall, or the working become inferior to what it is, and to what it has been for some time past, we are liable to find competitors in the field. But, gentlemen, we trust that is a matter that will not occur. It certainly shall not be from any want of exertion on our part. Then, again, we must always bear in mind that our line is a very excellent and a very perfect one; in fact, more perfect now than when it was first constructed, because not only do we repair everything that goes wrong during the year, but as science and experience improve and increase from time to time, we improve the line in accordance with the latest improvement. But notwithstanding that it is only valuable as a going concern. If there were some convulsion—political convulsion—that were to destroy the line, it would be of no value whatever. I mention that simply as one of the many arguments for keeping up and greatly increasing our reserve. Well, gentlemen, I think with those few remarks, which I am afraid have been rather tedious, and which are all I have to say at present, I will submit the resolution I have read to you.

A SHAREHOLDER: Some misconception might arise from your remarks about the reduction of the tariff; it is to be hoped that the increase of traffic may compensate for that.

The CHAIRMAN: Well, it may or it may not. We always have the hope that where a reduction of tariff is made it may lead to an increase of traffic.

The motion was then put and carried unanimously.

A dividend for the half-year of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 30s. per share, both free of income-tax, making 12 per cent. for the year, were declared.

The retiring Directors and Auditors were re-elected; and a vote of nks to the Chairman and Directors then terminated the proceedings.

The Oriental Telephone Company (Limited).

The sixth ordinary annual general meeting of this Company was held on Tuesday last at the City Terminus Hotel, Cannon-street, Mr. W. Addison presiding.

The SECRETARY (Mr. Alexander B. Chalmers) read the notice convening the meeting, and the report of the directors and statement of accounts were taken as read.

The CHAIRMAN: Gentlemen, before moving the adoption of the report I will proceed to make a few remarks, and I think I shall be able to show you that the progress of the Company for the past year is more satisfactory than would appear from a cursory glance at the accounts. You will see that the balance-sheet we have issued is in a different form to previous ones, and which we believe the general public will be more readily able to understand. Our holdings of shares in the different companies are set out in a simpler and more intelligent manner, the deferred shares not being included in the valued assets, although as the terms for the guarantees draw near they really become a very valuable property. In noticing the accounts you will in the first place see by a note in the profit and loss account that a sum of £935 taken credit for last year really belonged to the year before—that is, to 1883. It represents the amount of guaranteed interest on the Bengal and Bombay Companies' shares held by this Company for that year, and that was the way in which it was dealt with by the auditors,

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whereas for the year 1885 it is for 12 months only. The accounts this time are charged with an item of income tax, £122, which really does not belong to 1885, but to the previous twelve months. The income-tax becomes due every year in April, and it has been the custom heretofore to charge it only when actually paid. We have debited the accounts this time with three-fourths of the income-tax, that brings us up to December last. I am happy to say that although we were assessed by the commissioners of income-tax to the amount of £146 last year, owing to our representation that we were not paying a dividend, they have, since the issue of the report, allowed our claim for exemption. In reference to the sum of £480 written off for depreciation of stores, half of that, I may say, hardly belongs to last year, as it is for material sent out in the early days of the Company, which has become practically obsolete. We have had a loss of £350 at Colombo, chiefly due to reconstruction expenses and a defalcation at Mauritius, which, I am glad to say, is not so serious as at first expected. The last advices leave us to hope that £200 will cover this item, and our new agent there writes more hopefully of the position generally. I may remark that Mauritius is a very difficult place to correspond with. The mail from there generally arrives two days after the mail goes out. Consequently it takes about three months to get a reply. Unfortunately, all our exchanges are in towns particularly affected by the bad times, and the heavy fall of the Eastern exchanges has largely reduced our profits for the last year. During that time, however, the business in Egypt has greatly improved. The Directors of the Egyptian Company declared a dividend at the rate of 5 per cent. for last year, as against 3½ per cent. for the previous twelve months The shares are still valued in the accounts at less than half their nominal value. Since their accounts for 1885 were made out the business has steadily continued to improve. The Indian guarantees are gradually decreasing, but not so fast as we should like to see them. The Bengal Company for the last 12 months shows a decrease of £650 and the Bombay Company a decrease of £600. I may remind you that the guarantee to the former company expires in May, 1888, and to the latter in September, 1887. After these guarantees cease our deferred shares come in and share equally with the others, so that instead of guaranteeing 8 per cent. we shall be receiving a percentage on our holdings, whatever they may be. The total number of new subscribers is 537. On the other hand, the withdrawals, owing to failures and bad times, have been 206, leaving a net increase of 331. The total number of subscribers up to December 31st, 1885, was 1,889, as against 1,578 in December, 1884, and the total number up to the latest advices this year—which we may take to be the middle of March—is 1,984. These returns we think fairly good, considering the commercial depression existing everywhere. We have taken £500 for our remuneration for the past year, and propose to take only the same amount for the current year. In conclusion, you will see by the accounts that our financial position, with £2,000 on deposit at the bank, and nearly £1,000 on current account, and other £600 at our agencies abroad, is by no means an unsatisfactory one, and we trust the shareholders will think so also. I now beg to move the adoption of the report and accounts, and if any shareholder wishes to ask any questions before I put the motion I shall be glad to answer them.

The Right Hon. G. A. CAVENDISH BENTINCK, M.P., seconded the motion, which was carried unanimously, without discussion.

The CHAIRMAN then moved the re-election of Mr. Henry Grewing as a Director, and Mr. B. ST. JOHN ACKERS having seconded the resolution, it was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. G. B. FROST, Mr. Thomas Lloyd was also re-elected to his seat at the Board.

Mr. BAKER in, a few words, warmly acknowledged the report and services of the committee that was appointed to investigate the affairs of the Company under its previous *régime*, and proposed that a cheque of 200 guineas be awarded to the members composing it, in recognition of their labours—a motion which was seconded by Mr. FITZGERALD and agreed to *nem con.*

Mr. FITZGERALD next moved, and Mr. CUFF seconded, the re-appointment of the Company's auditors, Messrs. Deloitte, Dever, Griffiths, and Co., at a remuneration of 50 guineas for the current year, which was unanimously agreed to.

Mr. BAKER afterwards proposed, and Mr. BUCKINGHAM seconded, a vote of thanks to the Chairman and Directors.

The CHAIRMAN having briefly returned thanks,

The meeting was made extraordinary, when,

The SOLICITOR to the Company, Mr. Joseph Addison (Linklater and Co.), said that it had been thought expedient to alter the Articles of Association in the direction of withdrawing from the Directors certain powers, which it was thought were too wide for them to exercise without the consent of the shareholders. He then proceeded to explain the nature of the proposed modifications, which were as follows:—That Article 56 of the Articles of the Association of the Company be altered by striking out the words "But this Article shall be construed as being only directory." That Article 60, clause (*a*), be altered by the addition of the following words:—"Provided that the total amount for the time being owing shall not, without the previous consent of a general meeting of the Company, exceed £10,000," To add the following words at the end of amended clause (*c*) of the same Article after the words "or other interests:—"But the authority hereby conferred is not to be deemed to authorise the sale of the entire business or undertaking of the Company without the previous consent of a general meeting." That clause (*d*) in the same Article be rescinded and the following sub stituted:—"They may from time to time appoint any one or more of their number managing director or managing directors, with such share or proportion of the remuneration payable for the time being under Article 58, and for such period as they deem fit." To add the following words to clause (*e*) of the same Article:—"Subject to confirmation at the next annual meeting." To insert in clause (*f*) of the same Article after the words "they may," in the first line, the following words, viz:—"Subject to the limitations imposed by paragraph (*a*) of this Article." That Article 61 be altered by the addition of the following words after the words "the continuing directors" in the first line:—"So long as their number for the time being is not less than five." That Article 64 be rescinded, and the following be adopted in its place:—"No contract or arrangement entered into by or on behalf of the Company with any company, corporation or partnership, of or in which any Director shall be a member or otherwise interested, shall be avoided, nor shall any Director being such member, or so interested, be liable to account to the Company for any profit realised by any such contract or arrangement by reason only of such Director holding such office, or of the fiduciary relation thereby established; but no such Director shall vote in respect of any such contract or arrangement."

On the motion of the CHAIRMAN, seconded by Mr. B. ST. JOHN ACKERS, the whole of the foregoing alterations in the Articles were agreed to, and the proceedings terminated.

Reuter's Telegram Company.

The report of the Directors of this Company, which was presented at the general meeting on the 22nd inst., states that in the circular issued last October, the shareholders were informed of the heavy expenses entailed by the successive campaigns in the Soudan and the Anglo-Russian crisis. The anticipations which were then entertained, that the exceptional state of political affairs had ceased were unfortunately not realised, the Servo-Bulgarian and the Burmese wars having followed immediately afterwards. The Directors regret that, owing to these causes, the results of the year's operations do not admit of a dividend being declared. They have, however, the satisfaction to announce to the shareholders that new arrangements have been entered into with the Press, which provide for future exceptional expenditure in time of war or prolonged political disturbance. The Directors regret to have to record the death of their esteemed colleague, Mr. James Sydney Stopford. It is not proposed to fill up at present the vacancy thereby created on the Board. Admiral the Right Hon. Sir John C. D. Hay, Bart., K.C.B., retires from the direction, but offers himself for re-election. The auditors, Messrs. Quilter, Ball, and Co., also offer themselves for re-election.

A report of the meeting of the shareholders will be given in our next issue.

NOTICE OF REMOVAL.—The Western Electric Company notify that they have removed to new premises at 79, Coleman-street, London, E.C.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices. April 20.		Business Done Week Ending April 20. Highest.	Lowest.
Anglo-American	30½,	31½	35¼	30⅝xd
Do. Preferred	52,	53	58½	51½xd
Do. Deferred	9½,	10	11¾	9½
Brazilian Submarine	10⅝,	11⅛	11 3-16	10⅞
Cuba	10½,	11	10 11-16	10¼
Do. Preference	18,	19	—	—
Direct Spanish	1½,	2	—	—
Do. Preference	10	10½	—	—
Direct United States Cable	8¾,	9¼	9 15-16	8⅝xd
Eastern Telegraph	11¼,	11½	11 13-16	11⅜xd
Do. 6 per Cent. Preference	14⅛,	14⅜	14	—xd
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12¼,	12⅝	12¾	12½xd &
German Union	9½,	10	—	—[bonus
Globe Telegraph and Trust	6½,	6¾	7	6 9-16xd
Do. Preference	13¾,	14¼	13½	13 7-16xd
Great Northern	14,	14½	14 5-16	14 1-16
Indo-European	37½,	38½	—	—
Reuter's	6¼,	6¾	6¼	6⅛
Submarine	200,	210	—	—
West India and Panama	¾,	1	13-16	—
Do. 1st Preference	9¼,	9¾	9⅜	9½
Western Brazilian	7⅜,	7⅝	—	—
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Companies.	Closing Prices. April 20.		Highest.	Lowest.
Consolid. Telephone and Maintenance	15-16,	1 1-16	1	—
Oriental	3-16,	5-16	—	—
United Telephone	12¼,	13¼	13	12 15-16

ELECTRIC LIGHT.

Companies.	Closing Prices. April 20.		Highest.	Lowest.
Anglo-American Brush Light (£7 paid)	3,	3½	—	—
Do. (fully paid)	5,	5½	—	—
Hammond Light (£8 15s. paid)	1-16,	3-16	—	—
Swan	1,	1½	1	—
Maxim-Weston	¼,	⅜	5-16	—

MISCELLANEOUS.

Companies.	Closing Prices. April 20.		Highest.	Lowest.
Telegraph Construction	36½,	37½	37½	—
India Rubber, Gutta Percha, and Telegraph Works	23	24	23¾	23

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NOTES.

OURAY-COLORADO.—A company has been organised to erect a telegraph line from Ouray to Montrose, and work on the line has been commenced.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 23rd inst. amounted to £2,487.

PARIS.—MM. Leconteux and Garnier are putting the electric light into the *Magasins de la Belle Jardinière*, and will use about 200 Edison lamps supplied from a Breguet dynamo.

THE LAW COURTS.—The telephone will shortly be introduced into the Law Courts, for the use of the gentlemen of the long robe and others having an official connection with the courts.

A NEW USE FOR THE PIANO.—A new feat in the way of electric lighting is the application of cell storage to pianos. The case of the instrument conceals the materials for an illumination lasting over ten hours.

BENGAL.—We learn that the system hitherto in use at the Central Exchange of the Bengal Telephone Company is to be changed, and that the Magneto-Bell will take the place of the Law system throughout the company's exchanges.

DAMAGES AGAINST A CONTRACTOR.—*L'Ingénieur-Conseil* mentions a judgment passed by a Paris tribunal giving heavy damages against a contractor for electric light, because a valuable picture was burnt in a fire arising from defective installation.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 23rd inst. were £1,999, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ELECTRIC LIGHT AT CLUMBER.—At the celebration of the coming of age of the Duke of Newcastle, on Wednesday last, when a banquet to his friends and principal tenants was given in the courtyard at Clumber, the buildings were illuminated with the electric light.

ELECTRIC LIGHTING ACT COMMITTEE.—Mr. W. H. Massey, electrical engineer in the Royal Household, has retired from Lord Thurlow's Committee, in consequence of the action taken recently by the executive council with reference to the Bills now before the House of Lords.

ELECTRIC LIGHTING.—We understand that the Conservatoire des Arts et Métiers is to be lighted by electricity. The inauguration, we believe, takes place on the occasion of the meeting of the several scientific congresses which generally assemble in Paris during this week.

LIVERPOOL EXHIBITION.—The Liverpool Electric Supply Company, having secured the contract of the lighting of the "Shipperies" Exhibition throughout with the electric light, have placed the order for all the cables and wire required therefor with Messrs. Walter T. Glover and Co., Salford, Manchester.

ELECTRICIANS FOR CHATHAM.—An electrical staff is to be formed at Chatham Dockyard, from which a certain number of the best fitters are to be sent to Portsmouth. On the completion of a course of training they will return to Chatham, and form the nucleus of a permanent staff of electricians at that establishment.

ELECTRICITY IN MINES.—It will be remembered that the report of the Lighting of Mines Commission, objected altogether to the use of the electric light, in that it would not give any indication as to the state of the mines in reference to fire damp. We have at various times described electrical apparatus for indicating fire damp, and this week, in another column, we describe another instrument which comes to us from America.

MORE EXHIBITIONS.—The first International Exhibition under the auspices of the National Society of Science and Art will be held at Paris in the Palais de l'Industrie, so well known to many of us from the Exhibition of 1881, from July to November this year. One group is reserved for electrical exhibits. At the Maritime Exhibition at Havre, to be opened on the 1st May next year, the application of electricity to ships and maritime operations generally will form a prominent feature.

EARTH CURRENTS.—M. Mascart describes a considerable magnetic disturbance which began on the 30th March about half-past eight in the morning. The disturbance continued till the 31st, then got gradually weaker, and disappeared completely on the 1st of April. This phenomenon, which was observed at Parc Saint-Maur, had been noticed at the same time at the observatories of Lyons, of Perpignan, and of Nice. It will be seen that this storm is the same as that referred to in our note, p. 404, of April 2nd.

THE BUILDING TRADES AND ARCHITECTURAL EXHIBITION. The following firms were successful in obtaining awards at the recent exhibition at the Agricultural Hall:—E. Jacobs and Co. (gas engine), Julius Sax (general excellence in electrical appliances), Cordner, Allen, and Co. ("Byng" Telephone), J. Davis and Co. (scientific instruments, &c.), Sanderson and Co. (lightning conductors), W. F. Stanley (mathematical instruments, &c.), G. A. Williams (automatic oxy-hydrogen light apparatus, &c.), and Messrs. Howard and Haig (general electrical appliances, &c.)

A NEW LIGHT.—A new competitor to gas and electricity is said to be found in a new medium of light called the "Lucigen," for which, among other advantages, it is claimed that it yields an illumination equal to 2,000 candle-power actual, at a cost of about 2d. per hour, while the cost of the necessary plant is one-fourth that required for electric lighting. The Lucigen is produced by burning heavy hydro-carbon oils in a specially made burner by means of compressed air or steam. The oil is burned in the form of a fine spray, and, without giving off any smoke or smell, lights up a radius of 200 yards around each burner. It has been used chiefly to light large spaces.

SWIFT OCEAN STEAMERS.—Lord Alfred S. Churchill, writing to *The Times*, with regard to the loss of the "Oregon," says: "The fact is that these great American liners travel at such a speed—viz., from 16 to 20 miles an hour—that on a dark night they come upon a strange vessel so rapidly that neither of them has much chance of avoiding a collision if not seen at at some distance off. My proposal is that these fast steamers should be fitted with electric search lights similar to those now in use on war ships, and that through the whole night these should be kept at work sweeping the horizon in front of and on either bow of the ship."

AN ELEVATED ELECTRIC RAILWAY VETOED.—A Bill passed by the City Councils of St. Louis has been vetoed by the Mayor, who says in his message: "An elevated railway, with electricity as the exclusive motive power, to be restricted to the carrying of passengers, would be a credit to the city and undoubtedly a benefit to the people at large; but the rights of property damaged by its construction should be securely protected, and the Bill should be so framed as to leave no question as to the exclusion of steam as a motor, or as to the possibility of its being converted into a freight road while in the hands of its projectors or their successors."

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THE MAGNET IN MILLING.—One of the small things which will help the buhr miller is the use of the magnet. It is supposed by many that any device so simple and efficient as the magnet would be in every mill, but it is not. They make a separation which cannot be made by any other device. When the wire binders came into use some of the millers thought it would be necessary to exterminate them by refusing to buy wheat from the field in which they had been used. The magnets pacified them, and showed that there was more metal in other forms than wire to be taken out than the wire itself, even from the wheat on which the wire binders had been used. *Millstone.*

ELECTRIC TRAMWAY LOCOMOTION.—This is the title of a report in the *Leytonstone Express* of a private trial trip. From a scientific or a practical point of view this report is absolutely valueless. It simply tells that a car was propelled, the work being done by electric energy from seventy storage cells. Certain surmises are indulged in which give credit to fancies instead of facts. Why cannot we get independent examination by some such body as the Royal Agricultural Society? Surely cheap locomotion comes within the aims of the society. Let prizes be offered and trials made, then the results will be valuable; but surely to say a car was run up and down a line, and the batteries would continue working for so many more hours is a waste of time, ink, and paper.

UNDERGROUND WIRES.—We have consistently advocated the introduction of underground wires for telephonic purposes in large towns, and we believe we are correct in saying that the Bell Telephone Company of New York have practically adopted the Brooks system for underground wires, and no doubt we shall have to chronicle the laying of a large amount of the wires according to this system during the ensuing summer. The experience of our own telegraph department with these wires, if published, might be valuable. It may be remembered that Mr. Brooks was himself over in England in 1881 to superintend the extension of his system for the Post Office. The time that has elapsed since then must have been sufficient to give a fair trial to the system.

A NEW ELECTRIC LAMP.—The new incandescent lamp of Max Neuthel, which has been patented in Germany, dispenses with a vacuum. The filament consists of a mixture of conductors and non-conductors of electricity, being composed of magnesia and porcelain clay, saturated with platiniridium salts, and afterwards heated to incandescence in order to reduce the absorbed salts to the metallic state. The inventor supposes that the electric spark jumps from one particle to another, causing a heating action of the non-conducting substances, which are thus brought to incandescence and emit a strong steady light. The filaments are to be strengthened, when deemed necessary, by a covering of chrome, the melting point of which is still higher than that of platinum.

THE TELEPHONE.—Considering the period during which it has been in existence, the telephone has made more remarkable progress than any other invention. The number of instruments in use in the United States in 1877 was only 780, whereas in February, 1880, there were 60,800; in 1883, 249,700; in 1884, 307,010; and in February, 1885, 325,574. There are about 18,000 telephones in Canada, and only about 13,000 in Great Britain. The number of exchanges has grown from 100 in 1880 to 782 in 1885. In January last there were 137,223 miles of telephone wire in the United States. There are 5,186 persons constantly employed by the exchanges. More different patents have been issued on the telephone than in any other single line of invention in America. The total number for the last ten years is 1,521.

PROF. HENRY'S BIG MAGNET AND BATTERY.—Among the many valuable and historic pieces of apparatus about Yale college are several instruments which were invented and used by the late Prof. Henry in his experiments on electricity. In one of the laboratories of the school of science may be found his "big magnet," as it is called, mounted on a large frame, which, when charged with electricity by means of his "big battery" of one cell, was capable of lifting 3,300 pounds. He afterwards made one of nearly the same size and capacity for Yale, which has been in constant use there until within a few years, when it was laid aside, and is now preserved among other relics of the college. Prof. Henry's large magnetic globe, made partly of wood, constructed so as to show the electric current of the earth and the dipping of the needle, together with his galvanometers, coils, electro-magnets, and recorders, are of special interest and of peculiar historical value.—*Princetonian.*

FEMALE TELEGRAPH CLERKS.—If we are to judge by a correspondence that has recently been conducted in the *Standard*, the employment of young ladies as clerks in the Post Office is not an unmixed advantage to this branch of the public service. The writers, one and all, complain of the want of civility shown by the fair usurpers of the quill, not to speak of their utter disregard of the homely aphorism, "time is money." To a busy man certainly nothing can be more aggravating when he wants to despatch a telegram than to have to wait in a post office while the young ladies behind the counter (who ought to be alert to business) settle to their satisfaction the question of how a velvet dress should be trimmed, or what they ought to wear on Easter Monday. One correspondent suggests a remedy for this state of things—that there should be a male head in every office who would be responsible for discipline and order, and to whom the public might appeal in case of inattention or rudeness on the part of the female officials.

TELEPHONE EXPERIMENTS IN FRANCE.—The *Standard's* Paris correspondent states that new and interesting telephonic experiments have just taken place between Paris and Rheims, with the object of ascertaining whether persons provided with the telephone in Paris can correspond directly with telephone holders at Rheims. The distance separating Paris from Rheims is one hundred and seventy-two kilometres, but, including the length of the subterranean telephonic wires, the distance is two hundred and twenty kilometres. The lines serving for these experiments were two ordinary telegraphic wires, one of which was the Rheims wire, and the other the Berlin wire, which had been adapted to the public telephonic service organised between Paris and Rheims by means of M. Van Rysselberghe's anti-inductive system. This system permits of telegraphic and telephonic despatches being simultaneously transmitted by the same wires without the slightest confusion, so that while telephoning was going on between Paris and Rheims the same wires were traversed by telegraphic despatches exchanged between Paris, Rheims, and Berlin. All the experiments were perfectly successful.

THE EDINBURGH INTERNATIONAL EXHIBITION.—Satisfactory progress has been made in the preparations for the opening of the International Exhibition at Edinburgh. The building has cost £30,000. Applications for space have been numerous, 112,000ft. of which has been placed at the disposal of exhibitors, and that has all been taken up. The efforts made to get all the outside work accomplished before the opening day are likely to be successful. Groups, representing science and art, have been erected on high pedestals upon the flanking towers

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of the main entrance. Variegated lamps for the electric light are being suspended throughout the grounds, and a good idea can now be formed of the general arrangement, which promises to be very effective. The shades for the incandescent lamps are coloured pink, blue, and gold, and these will be festooned between three rows of tall poles, round the band stand and elsewhere in the grounds, about 1,200 in all being placed outside. An electric railway has been laid down along the northern promenade. There are in all fourteen dynamos, with six boilers, and four vertical and two horizontal engines. Four of the boilers are for electric lighting, and two supply the steam for the machinery in motion.

THE EASTER MANŒUVRES.—We copy the following from *The Times*' account of the Volunteer operations in the advance upon Dover on Saturday last:—"The signallers were posted at every suitable spot, and were vigilant, smart, and untiring. It is, however, noteworthy that one of Moncrieff's signalling parties read the message of one of the enemy's signalling parties to Moncrieff's advantage. This is a lesson that ciphers not easily to be interpreted by an adversary should be used in war. In connection with signalling, I may mention that a system of communicating from Canterbury with Dover over the heads of the invaders was arranged by Major Allatt, who has long devoted himself to this important subject, to which more attention is paid on the Continent than in this country. At 8:30 this morning one of Major Allatt's pigeons arrived at Dover with a written message attached to it, stating that the enemy was advancing." We learn from another source that the Post Office riflemen, who took a conspicuous part in the turning movement on Lydden Hill, acquitted themselves in a manner which drew from their commanding officers the highest encomiums. A company of these men marched from Canterbury, and were foremost on the Lydden Hill without dropping a single man, notwithstanding the fact that they were in heavy marching order; whilst the casualties on the road in other Volunteer regiments, all of whom were lightly equipped, could be counted by hundreds.

DIFFERENCE BETWEEN POSITIVE AND NEGATIVE ELECTRICITY.—Dr. Wachter, of Vienna, has recently communicated to the Academy of Science in that town a paper, in which he attempts to prove that, contrary to the generally accepted belief, crediting positive and negative electricity with absolutely analogous properties differing only in sign, there are between them many points of diversity. He maintains that the properties of the two electricities are totally different, and these differences manifest themselves in regard to (1) equipotential surfaces, (2) direction of movement, (3) magnetic, (4) thermic, and (5) optic properties; also (6) in regard to the substances electrified. Dr. Wachter treats only of the first and second headings. He asserts that in conductors of great specific resistance the point where the potential has a mean value lies, not midway between the extreme ends of the conductor, but somewhat nearer the negative end. If equal quantities of positive and negative electricity accumulate respectively on two conductors of equal size, the potential, measured by means of an electrometer, has a greater value, irrespective of the sign, on the positive than on the negative conductor. The electric mill revolves in the direction of the flow of positive electricity, which proves that the movement of the molecules of air around a positive and negative point is different. The appearance of the discharge from such points is also different, indicating an inequality in the equipotential surfaces.

THE ELECTRIC LIGHT IN MINES.—We have been favoured by Mr T. Connolly with an advance proof of his paper read before the Manchester Geological Society, which we referred to in our last issue, pointing out that the *Athenæum* was—so far as its scientific information is concerned—behind the times. As we expected, Mr. Connolly's paper does not bear the construction put upon it by our contemporary. It may be interesting to give, briefly, Mr. Connolly's conclusions:—"Can we bring the electric light into practical use? Now, in carrying out this notion, I would like to combine, as far as I am concerned, the two systems—that is, the system of the conveyance of the electric current through all the main roads—everywhere as far as you can go up to the lamp station. In a large colliery, where it is so arranged, I think with every chance of safety, it could be carried up to that point, at all events, and even beyond; but assuming that it may be carried so far, let us see how it may be done in a practical manner. The difficulty has been suggested of providing against accidents by falls. I will suggest a means by which this may be overcome. We have a cable at the present time with an insulation which ten years ago could not have been got for four times the cost. It is the result of long study, the object being to get the cheapest and best cable which would enable us to embark on enterprises like these and yet have a return for the capital expended. In cases of falls of roof, say of several tons weight, or of a crush, it may be said that this cable would be entirely squeezed up. I venture to think that it would take a good deal more force than is ordinarily met with, unless it came in contact with jagged points, to crush through this insulation and render it incapable of retaining the current. . . . Now, supposing this system to be carried as far as the lamp station, would it be safe to carry it in-bye or no? In many cases I do not believe it would. Then we come back to the problem which is being fought out—the safety lamp of the miner;" which the author said was as yet not settled.

BLASTING OPERATION AT THE ROYAL ALBERT DOCK.—The wall which bounded the tidal basin of this dock on its north-east side, and which it was found necessary to remove to provide a new entrance suitable for the increased draught and dimensions of ocean liners, was successfully blown up last week by gelatine dynamite, fired by electricity. The total length of the wall was 520ft., and the estimated weight of material, flint, and pebble concrete 7,850 tons. The electrical wiring for the simultaneous discharge of the shots was carried out by Messrs. Siemens, who have the lighting of the docks, the plan of operations having been submitted by the Dock Company to Sir Frederick Abel. One of the alternating machines used for shed lighting, and in its ordinary working giving off a current of 48 amperes at 600 volts, was coupled up in series to develop a high tension current of 24 amperes at 1,200 volts, to suit it for firing the high tension Abel fuzes employed on the occasion, this being the first time that such a large number of this class of chemical fuses have been used, platinum wire or low tension fuses being usually adopted for this kind of operations. Two well insulated main leads of copper wire were brought from the ordinary electric lighting station beyond the Galleons Basin, and were carried along the rear of the wall. Two additional mains were also carried from the machine and united with the first mains about the middle and at the end of the wall, so that if any damage or defect occurred at any point in the transmission of the current it would have independent means of percolating the network system of branches which were taken off from the mains to the fuses. The transmitting mains were tapped at the firing station, erected near the bridge at the western extremity of the basin by a tumbler-switch, by a blow upon which the electrical current could be instantaneously put into circuit. The total length of branch wires was over six miles, and the total quan-

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tity of gelatine dynamite employed was stated to be 2,860lb. Six feet of the wall was above the level of the water in the basin.

THE WAR OF CABLE RATES.—It will be seen by the following table, says the *Daily News*, that the four united companies have an aggregate capital of nearly £12,700,000, and they have also large reserves in hand; while the Mackay-Bennett Company has little or no visible reserve in hand. For the sake of showing the position we add the percentages of gross receipts agreed on by the four older companies in the pool, together with a calculation, based on the traffic receipts of the Anglo-American Company for last half year, of the annual revenues respectively obtained by the combined companies when working at the rate of 1s. 8d. per word. This rate, although high enough for the commercial community, has not satisfied the combined companies, and they are therefore attempting to "freeze out" the non-conforming company by reducing the rates to the basis of 6d. per word :—

No. of Cables.	Company.	Capital.	Proportion in Pool.	Being (at 1s. 8d. per word) yearly
4	Anglo-American	£7,000,000	49 p.c.	£280,000
2	American Tel. and Cable (guar. by West. Union).	2,800,000	22½ ,,	130,000
1	Direct U.S. Cable	1,214,000	16¼ ,,	92,000
1	Co. Francaise du Tel.	1,680,000	12¼ ,,	70,000
8	Totals	£12,694,000	100 ,,	£572,000

Early last year the Commercial Cable Company, the result of a partnership between Mr. Mackay, the capitalist, and Mr. Jas. Gordon Bennett, the newspaper owner, opened its wires to the public at a standard charge of 1s. 8d. per word. What Mr. Mackay's motives might have been over and above the general dollar-making motive which pushes on most American enterprises it is useless to guess about. He saw a monopoly, doubtless disliked it, and attempted to break it down. Profiting by the cheapness, or what then appeared to be cheapness, of copper and other material, he made two cables, understood to have cost barely £700,000 each. This is less than half the capital per cable of the Anglo-American Company, which owns four cables, and has a stock of £7,000,000 altogether. In addition to the advantage of a small prime cost, the new company had that of an independent entry into New York and other Atlantic ports. But this very independence brought upon it an enemy by land as well as by sea. The Western Union Telegraph Company has a virtual monopoly of the inland telegraphic system in the United States; and inasmuch as all the ocean cables are dependent on its services for the transmission of their messages to and from the interior, they are naturally disposed to make common cause against an intruder, like the Mackay line, which breaks into the fringe of the land line monopoly. The following circular, issued by the Commercial Cable Company, was published in yesterday's papers :—"We beg to inform you that on and after the 5th prox., until further notice, the rate for telegrams by this company's cables to all points in the United States of America, Canada, &c., will be reduced to 1s. per word, The 'pooled' Atlantic cable companies, consisting of the Anglo-American, Direct United States, French, and Western Union, have made strenuous efforts to induce this company to raise the tariff to 2s. 6d.; and as we have refused to accede to their wishes, they announce a sixpenny rate. It is known full well that this rate would result in a serious loss to all the companies, but the 'pooled' companies think by adopting this extreme measure the Commercial Cable Company will be forced to come to terms, and raise the price to the figure desired. The Commercial Cable Company commenced business at 1s. 8d. per word, being a reduction of 20 per cent. on the then existing charge; and the amount of patronage we have received proves that the rate is a popular one. It was the intention of the Commercial Cable Company to regard 40 cents as their maximum, gradually reducing the price as opportunity offered. The earnest wish of this company is to maintain the 1s. 8d. rate, and to this end we ask the public to make a temporary sacrifice by supporting us at 1s, on the assurance that if we are vigorously backed up now the tariff shall return to the original figure, viz., 1s. 8d." On this the *Standard* observes that "they may be quite sure the public will do nothing of the sort. It would not have done so even had the Mackay-Bennett Company been popular, because charity is not business. But this private concern has done nothing to enlist popular sympathies on this side. Its ways are said to be American, and, rightly or wrongly, its rivals accuse it of not sticking to the published tariff of 1s. 8d. per word. Rebates more or less heavy were, it is alleged, granted to large customers—hence, in part, the declaration of war. However this may be, if Messrs. Mackay and Bennett had bravely prepared for a good stand up fight by lowering their tariff to sixpence per word, or, if possible, less, and sticking to their guns, they would have had much more popular support and sympathy than they can now expect to receive."

PERSIA.—The first number of a new contemporary, the *Indian Engineer*, contains a contribution from Shiraz which shows most clearly that a telegrapher's position in Persia is not all rose leaves. Probably most people in England have an idea that Persia is never troubled with snow storms, but the opposite is the case. The correspondent says that on Christmas Eve he found it snowing heavily, and that it continued snowing nearly all day. About noon the wires on both sides of the station were interrupted. With great difficulty he managed to get home on being relieved in the evening at 7 o'clock, the snow having ceased falling at 4 o'clock. Subsequently it was found that the iron poles were down in all directions. The staff then commenced the repairs, and all that could be spared were out working on the line. The following is taken verbatim from the letter, and shows better than any words of ours the difficulties encountered by the profession in far-off lands :—"They had frightful weather, and at Khonah Khorah, where there is only a caravanserai and a chaperkhanah, they could get nothing to eat, and were nearly starved for two days. They got the International wire up, and Hamilton returned to Dehbeed; Aganoor to Abadeh. Hamilton on arriving at Dehbeed found that all wires were interrupted towards Shiraz, so he went out again (after the most trying weather and hard work he had in the pass between Dehbeed and Abadeh) repairing the line. He got to Moorghab after two or three days' hard work (Moorghab is 32 miles this side of Dehbeed). At Moorghab he felt seedy. Gifford, from Koomeshah Station, who had come to help Hamilton, arrived at Moorghab, and found Hamilton suffering from great pain in his stomach, and inflammation of the whole body. Gifford at once sent a chapar to Swand with a message for the doctor (there being no telegraphic communication then). On the doctor receiving the telegram from Swand he prescribed and left Shiraz chapar with medicines, &c., to see poor Hamilton, but before he reached Moorghab poor Hamilton had died (on 14th January). The poor fellow had suffered most agonising pain until he expired. He died from exposure to the severe weather and want of proper food. All the people in this telegraph department feel his loss. He came to his end facing such severe weather and doing his duty, and sacrificing himself in the performance of the same."

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ON THE USE OF THE BRIDGE AS AN INDUCTION BALANCE.

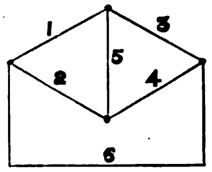
BY OLIVER HEAVISIDE.

In connection with a paper "On Electromagnets, &c.," that I wrote about six years ago, to be found in the *Journal* of the Society of Telegraph-Engineers and Electricians, which paper dealt mainly with the question of the influence of the electromagnetic induction of the lines and instruments on the magnitude of the signalling currents, an influence which is of the greatest importance on short lines, and which (of the instruments) is, even on long lines, where electrostatic induction is prominent, of importance as a retarding factor, I made a great many experiments on self-induction, amongst which were measurements of the inductances of various telegraph instruments, with a view to ascertaining their practical values, and also the multiplying powers of the iron cores. It was my intention to write a supplementary paper giving the results and also further investigations; but, having got involved, in the course of the experiments, in the difficult subject of magnetic inductivity, it was postponed, and then dropped out of mind.

I used, first of all, the bridge and condenser method described by Maxwell, with reversals, and a telephone for current indicator. This was to get results at once, or by simple calculations, in electro-magnetic units. Next, I discarded the condenser, and used the simple bridge, balancing coils against standard coils. Thirdly, I have used a differential telephone with the same object, in a similar manner. The two last are very sensitive methods, and the verifications of the theory of induction in linear conductors that I have made by them are numerous.

The whole of this journal would be required to give anything like a full investigation of the various ways of using the bridge as an induction balance. I can, therefore, only touch lightly on the subject of exact balances, especially as I have to remark upon faulty methods, approximate balances, and absolutely false balances. Prof. Hughes's balance is sometimes fairly approximate, sometimes quite false.

Put a telephone in the branch 5, battery and interrupter in 6. Then, r standing for resistance, l for inductance (coefficient



of self-induction), and x for l/r, the time constant of a branch, the conditions of a true and perfect balance, however the impressed force in 6 vary, are three in number, namely,

$$r_1 r_4 = r_2 r_3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$x_1 + x_4 = x_2 + x_3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$l_1 l_4 = l_2 l_3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Their interpretations are as follows:—If the first condition is fulfilled there will be no final current in 5 when a steady impressed force is put in 6. This is the condition for a true resistance balance.

If, in addition to this, the second condition be also satisfied, the integral extra current in 5 on making or breaking 6 is zero, besides the steady current being zero. (1) and (2) together therefore give an approximate induction balance with a true resistance balance.

If, in addition to (1) and (2), the third condition is satisfied, the extra current is zero at every moment during the transient state, and the balance is exact, however the impressed force in 6 vary.

Practically, take

$$r_1 = r_2, \quad \text{and} \quad l_1 = l_2, \quad . \quad . \quad . \quad . \quad (4)$$

that is, let branches 1 and 2 be of equal resistance and inductance. Then the second and third conditions become identical; and, to get perfect balances, we need only make

$$r_3 = r_4, \quad \text{and} \quad l_3 = l_4. \quad . \quad . \quad . \quad . \quad (5)$$

This is the method I have generally used, reducing the three conditions to two, whilst preserving exactness. It is also the simplest method. The mutual induction, if any, of 1 and 2, or of 3 and 4, does not influence the balance when this ratio of equality, $r_1 = r_2$, is employed (whether $l_1 = l_2$ or not). So branches 1 and 2 may consist of two similar wires wound together on the same bobbin to keep their temperatures equal.

The sensitiveness of the telephone has been greatly exaggerated. Altogether apart from the question of referring the sensitiveness to the human ear rather than to the telephone, it is certainly, under ordinary circumstances, often unable to appreciate the differences of the second order, which vanish when the third condition is satisfied. Thus (1) and (2) satisfied, but with (3) unsatisfied, will give silence. Take, for instance, $r_1 = r_2$ and $r_3 = r_4$, but l_1 different from l_2 and l_3 from l_4, then silence is given by

$$(l_1 - l_2)/r_1 = (l_3 - l_4)/r_3 \quad . \quad . \quad . \quad . \quad (6)$$

that is, by making the differences of the inductances on the two sides of 5 proportional to the resistances. We can therefore get silence by varying the inductance of any one or more of the four branches 1, 2, 3, 4, to suit equation (6). It is certain that we do get silence this way, but it does not follow that silence is given by *exactly* satisfying (6), (and (1) of course), because it is only a balance of integral extra currents, and other balances of this kind are certainly quite false sometimes. To avoid any doubt, it is of course best to keep to the legitimate and simpler previously-described method.

There are some other ways of using the bridge as an induction balance in an exact manner, but they are less practically useful than theoretically interesting. Pass, therefore, to other approximate, and to false balances. Suppose we start with a true balance, and then upset it by increasing the inductance of the branch 4. It is clear that we should never alter the already truly established resistance balance. Now, besides by the exact ways, we can get approximate silence by allowing mutual induction between 5 and any of the other five branches, or between 6 and any of the other five branches, that is nine ways, not counting combinations. (Put test coils in 5 and 6 with long leading wires, so that they may be carried about from one branch to another.) These approximate balances are all of the integral extra current only, and therefore imperfect, however nearly there may be silence. But the silences are of very different values.

I find, using fine wire coils, that mutual induction between 6 and 4 or between 6 and 3 gives silence (to my ear) with the true resistance balance, just like the approximate balance of equation (6) in which no mutual induction is allowed.

These are only two out of the nine ways. All the rest are bad. If the difference in the inductance of 3 and 4 be small, there is very nearly silence on using any of the other seven ways; but, the larger this difference is made, the louder becomes the "silence," and sometimes it is even a very loud noise, quite comparable to the original sound that was to be destroyed, even when the combinations 6 and 4 or 6 and 3, and the formerly-mentioned method give a silence that can be felt, with the true resistance balance.

It is certainly a rather remarkable thing that the one method out of these seven faulty ways which gave the very loudest sound was the 5 and 6 combination, which is Professor Hughes's method. I do not say that it is always the worst, although it was markedly so in my experiments to test the trustworthiness of the method. And sometimes it is quite fair. In fact, when the sound to be destroyed is itself weak, all the seven faulty methods are apparently alike, nearly true. But when we exaggerate the inequality of inductance between 3 and 4, whilst the 6 to 4 and 6 to 3 combinations keep good, the others get rapidly worse, and differences appear between them.

I found that by increasing the resistance of the branch whose inductance was the smaller, the sound was diminished greatly, *i.e.*, in the seven faulty methods. The coil of greater inductance had apparently the higher resistance. That is, with a false resistance balance we may approximate to silence. Such a balance is damned for scientific purposes.

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Although mutual induction between 6 and 4 or 6 and 3 gave silence, with true resistance balances, the experiments were not sufficiently extended to prove their general trustworthiness. There is, however, some reason to be given for their superiority. For, since the disturbance in the telephone arises from the inequality of the momenta of the currents in the branches 3 and 4, and of the electric impulses arising in them when contact is broken in branch 6 (considering the break only for simplicity), we go nearest to the root of the evil by generating an additional impulse in 3 or 4 themselves from the battery branch, of the right amount.

The following is an outline of the theory of these approximate balances. Let $r_1 r_4 = r_2 r_3$ first; so that, C standing for current, we have, in the steady state

$$C_1 = C_3 = C_4 r_4/r_3\,; \qquad C_2 = C_4\,; \qquad C_6 = C_4(1 + r_4/r_3)\,. \quad . \quad (7)$$

The momentum of the current in branch 1 is $l_1 C_1$, that in 2 is $l_2 C_2$, and so on. Consider the break, and the integral extra current that then arises from $l_1 C_1$. It is

$$l_1 C_1 \div \{r_1 + r_2 + r_5(r_3 + r_4)/(r_3 + r_4 + r_5)\},$$

and $(r_3 + r_4)/(r_3 + r_4 + r_5)$ is the fraction of this that goes through 5; so that the integral current in 5 due to $l_1 C_1$ is

$$l_1 C_1 (r_3 + r_4) \div \{(r_1 + r_2)(r_3 + r_4) + r_5(r_1 + r_2 + r_3 + r_4)\}$$

or

$$C_4 r_4 x_1 \div \{r_3 + r_4 + r_5 + r_3 r_5/r_1\}$$

by making use of equations (1) and (7).

Treat the others similarly. The total extra current in 5 is

$$r_4 C_4 (x_1 + x_4 - x_2 - x_3) \div \{r_3 + r_4 + r_5 + r_3 r_5/r_1\} \quad . \quad . \quad (8)$$

without any mutual induction. So

$$x_1 + x_4 = x_2 + x_3$$

gives approximate balance. This was mentioned before, and becomes an exact balance with makes and breaks when a ratio of equality is taken.

Now let there be mutual induction between 6 and 4, 5 and 4, and 5 and 6, the mutual inductances being M_{64}, &c. Treating these similarly to before, we shall find the total extra current in 5 on the break taking place to be

$$\{r_4(x_1 + x_4 - x_2 - x_3) + M_{64}(1 + r_4/r_3) + M_{54}(1 + r_3/r_1)$$
$$+ M_{56}(1 + r_3/r_1)(1 + r_4/r_3)\}C_4 \div (r_3 + r_4 + r_5 + r_3 r_5/r_1)\,. \quad (9)$$

The theory of the make leads to the same result—that is, as regards the *integral* extra current. Otherwise they are different. So, using M_{56} (Hughes's method) the zero integral current is when

$$r_4\,(x_1 + x_4 - x_2 - x_3) + M_{56}\,(1 + r_3/r_1)\,(1 + r_4/r_3) = 0 \quad (10)$$

Using M_{45} we have

$$r_4\,(x_1 + x_4 - x_2 - x_3) + M_{45}\,(1 + r_3/r_1) = 0\,. \quad . \quad (11)$$

Using M_{64} we have

$$r_4\,(x_1 + x_4 - x_2 - x_3) + M_{64}\,(1 + r_4/r_3) = 0 \quad . \quad (12)$$

Practically employ a ratio of equality $r_1 = r_2$, $l_1 = l_2$—that is, make branches 1 and 2 equal fixtures. Then these three equations become

$$l_4 - l_3 + 2M_{56}(1 + r_3/r_1) = 0, \quad . \quad . \quad . \quad (10a)$$
$$l_4 - l_3 + M_{54}\,(1 + r_3/r_1) = 0, \quad . \quad . \quad . \quad (11a)$$
$$l_4 - l_3 + 2M_{46} = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (12a)$$

Thus the M_{46} system has the simplest formula, as well as being practically perfect. It is the same with M_{63}. Either of these must equal half the difference of the inductances of 3 and 4.

As (10*a*), or, more generally (10) contains resistances, we cannot get any definite results from Prof. Hughes's numbers without a knowledge of the resistances concerned. Note, also, that (10) and (11) are faulty balances; to improve them, destroy the resistance balance; of course then the formula will change, and is likely to become very complex.

It will be understood that when I speak of false resistance balances in this paper I do not in any way refer to the thick wire phenomenon, mentioned in my letter on p. 471, April 23, which, from its very nature, requires the resistance balance to be upset, or be different from what it would be if the wire were thin, but of the same real resistance. The resistance balance must be upset in a perfect arrangement. Nor can there be a true balance got, but only an approximate one, unless a similar thick wire be employed to produce balance.

What I refer to here is the upsetting of the true resistance balance when there is no perceptible departure whatever from the linear theory. The two effects may be mixed.

To use the bridge to speedily and accurately measure the inductance of a coil, we should have a set of proper standard coils, of known inductance and resistance, together with a coil of variable inductance, *i.e.*, two coils in sequence, one of which can be turned round, so as to vary the inductance from a minimum to a maximum. (The scale of this variable coil could be calibrated by (12*a*), first taking care that the resistance balance did not require to be upset.) This set of coils, in or out of circuit according to plugs, to form say branch 3, the coil to be measured to be in branch 4. Ratio of equality. Branches 1 and 2 equal. Of course inductionless, or practically inductionless resistances are also required, to get and keep the resistance balance.

The only step to this I have made (this was some years ago) in my experiments, which, of course, were mere dabbling, was to have a number of little equal unit coils, and two or three multiples; and get exact balance by allowing induction between two little ones, with no exact measurement of the fraction of a unit.

So long as we keep to coils we can swamp all the irregularities due to leading wires, &c., or easily neutralise them, and therefore easily obtain considerable accuracy. With short wires, however, it is a different matter. The inductance of a circuit is a definite quantity. So is the mutual inductance of two circuits. Also, when coils are connected together, each forms so nearly a closed circuit that it can be taken as such, so that we can add and subtract inductances, and localise them definitely as belonging to this or that part of a circuit. But this simplicity is, to a great extent, lost when we deal with short wires, unless they are bent round so as to make nearly closed circuits. We cannot fix the inductance of a straight wire, taken by itself. It has no meaning, strictly speaking. The return current has to be considered. Balances can always be got, but as regards the interpretation, that will depend upon the configuration of the apparatus.

Speaking with diffidence, having little experience with short wires, I should recommend 1 and 2 to be two equal wires, of any convenient length, twisted together, joined at one end, of course slightly separated at the other, where they join the telephone wires, also twisted. The exact arrangement of 3 and 4 will depend on circumstances. But always use a long wire rather than a short one (experimental wire). If this is in branch 4, let branch 3 consist of the standard coils (of appropriate size), and adjust *them*, inserting if necessary, coils in series with 4 also. Of course I regard the matter from the point of view of getting easily interpretable results.

The exact balance (1), (2), (3) above is quite special. If the branches 1 and 3 consist of any combination of conductors and condensers, with induction in masses of metal allowed, and branches 2 and 4 consist of an exactly equal combination, in every respect, there will never be any current in 5 due to impressed force in 6. And more generally $2 + 4$ may be only a copy of $1 + 3$, on a reduced scale, so to speak.

P.S.—April 27, 1886. The great exactness with which, when a ratio of equality is used, the M_{64} and M_{63} methods conform to the true resistance balance, as above mentioned, together with the almost persistent departure of the M_{65} (Hughes's) method from the true resistance balance, led me to suspect that, as in the use of the simple Bridge method, with no mutual induction, the three conditions of a true balance are reduced to two by a ratio of equality, the same thing happens in the M_{64} and M_{63} methods, but not in the M_{65}. This I have verified.

In Hughes's system, the three conditions are

$$r_1 r_4 = r_2 r_3, \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$
$$r_4(x_1 + x_4 - x_2 - x_3) + M_{56}(1 + r_3/r_1)(1 + r_4/r_3) = 0, \quad . \quad (14)$$
$$l_1 l_4 - l_2 l_3 + M_{56}(l_1 + l_2 + l_3 + l_4) = 0. \quad . \quad . \quad (15)$$

Now take $l_1 = l_2$, $r_1 = r_2$, $r_3 = r_4$; then the second and third are equivalent to

$$l_4 - l_3 + 2M(1 + r_3/r_1) = 0, \qquad 2x_1/x_3 = 1 + l_4/l_3.$$

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The second of these is a *special relation* that must hold before the first is true. Hence the sound with a true resistance balance, and the necessity of a false balance to get rid of it.

But in the M_{64} method the conditions are

$$r_1 r_4 = r_2 r_3, \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

$$r_4(x_1 + x_4 - x_2 - x_3) + M_{64}(1 + r_2/r_1) = 0, \quad . \quad (17)$$

$$l_1 l_4 - l_2 l_3 + M_{64}(l_1 + l_2) = 0. \quad . \quad . \quad . \quad (18)$$

Take $l_1 = l_2$, $r_1 = r_2$, $r_3 = r_4$, as before, and *now* the second and third conditions become identical, viz.,

$$l_4 - l_3 + 2M_{64} = 0,$$

agreeing with the previously obtained equation (12*a*).

Thus, whilst Hughes's method is inaccurate, sometimes greatly so, we may employ the M_{64} and M_{63} methods without any hesitation, provided a ratio of equality be kept to. They will be as accurate as the simple bridge method, and the choice of the methods will be purely a matter of convenience.

I have verified experimentally that the Hughes system requires a false resistance balance when, instead of coils, short wires are used, the branch of greater inductance having apparently the greater resistance. I have also verified that this effect is mixed with the thick wire effect, which last is completely isolated by using the proper M_{64} method or the simple bridge. Its magnitude can now be exactly measured, free from the errors of a faulty method. That is, it can be estimated for any particular speed of intermittences or reversals, for it is not a constant effect. Balance a very thin against a very thick wire, so that the effect occurs only on *one* side.

CARLETON'S FIRE-DAMP INDICATOR.

This apparatus for indicating fire-damp, says *The Engineering and Mining Journal*, was invented by Henry Guy Carleton, of New York. It consists, essentially, of one or more indicating balances to be permanently placed in a goaf or drift of the mine, and a registering balance to be used by the observer in the testing room, connected by well insulated wires. Each balance holds in equilibrium a thin glass bulb of about 300 cubic inches' capacity, hermetically sealed. They are counterbalanced at the same moment by the weights W and W′, respectively, as shown in the accompanying illustrations, and hence will be equally affected by future variations in the atmospheric pressure. Attached to the vertical arm or pointer H of each balance is a soft iron needle, *d*, gilded to prevent rusting. Its ends plunge freely into helices of insulated wire, *a* and *b*.

The helices on both instruments are exactly of the same size and electrical resistance, and of sufficient internal diameter to exert but feeble influence on the needles with an ordinary current. The right hand helix of balance No. 1 is connected with the right hand helix of balance No. 2, and is supplied at will from the battery I I with current whose strength can be lessened gradually and delicately by resistances thrown into the circuit by the rheostat, enabling the magnetic force of the helices to be regulated to a nicety. The left hand helices are similarly connected through battery I and rheostat.

The vertical arm H of balance No. 2 has a platinum tip capable of electrical contact with the insulated screw *c*. Connection from binding post 4 to the vertical arm is made by means of the mercury cup *m*, into which a wire from the beam is dipped. By contact between H and *c*, the relay in the observing room is kept closed. Breaking contact opens the relay, whose back-stroke shunts the local circuit on the bell, ringing it continuously. The resistance coil *g*, connected with binding-posts 3 and 4, prevents a spark passing when H and *c* break. The case surrounding balance No. 2 is of marble or unglazed tiling, excluding air currents and dust, yet admitting gases by diffusion. Chloride of calcium, in the holder D′, keeps the interior free from moisture. The whole is protected from injury by a perforated iron case, as shown. Once placed in its position in the mine, its temperature will be constant.

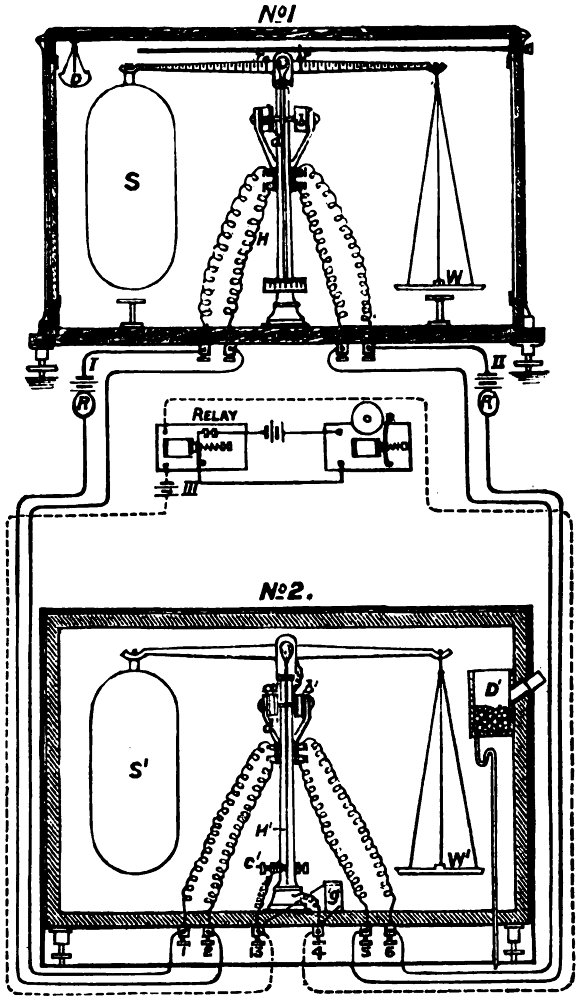
Balance No. 1, in the observing room, is provided with two riders, moved along the graduated beam, as shown. If more delicate readings are desired, additional riders of less weight may be also employed, a separate way being provided on the beam. Balance No. 1 is encased, dried by chloride of calcium, and placed in a room artificially maintained at constant temperature by means well known.

By this arrangement it will be seen :—

1st. That as the two bulbs S S′ are equal in bulk, and balanced at the same moment, they will be affected equally in weight by an increase or decrease in atmospheric pressure.

2nd. That the right hand helix of each instrument will exert the same amount of force on its responsive needle, both being supplied with current from the same battery, and that the same rule will apply to the left-hand helices.

3rd. That as each instrument is kept in an atmosphere of constant temperature and equal hygrometric condition, it will only be sensitive to a change in the pressure of said atmosphere or a change in its atomic weight.



Carleton's Fire-Damp Indicator.

Both instruments are balanced at the same moment by their weights W W′ respectively. The case of balance No. 2 is then filled with pure fire-damp at normal pressure, obtained from a "blower" in the mine. (This will obviate the necessity of correcting for that percentage of carbonic acid always associated with marsh gas in fire-damp, as would be necessary if pure marsh gas were used.)

Care, of course, is taken to keep a stream of the gas flowing in, to counteract the diffusion of air through the case. Bulb S′ will now sink, its increase in weight being about 39 grains, H will break contact with *c*, and the bell rings The observer now switches on battery I, which applies a force of, say, 45 grains, through helix *a′* to the needle attached to the vertical arm of balance No. 2. This more than compensates for the increase in weight, H is brought back to *c*, and the bell ceases to ring. The observer now throws in small resistances until H breaks again, and thus finally satisfies himself that the amount of force applied through helix *a′* of the distant instrument is

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just enough to balance it and no more. Now, as this amount of force is also exerted by helix *a* upon the needle of balance No. 1, its equilibrium is disturbed. Rider *r* is therefore shifted until equilibrium is restored. The position of this rider equals the force applied through helix *a*; equals the force applied through the helix of the distant instrument, No. 2; and necessarily equals the increased weight of the bulb S′ in pure fire-damp. From this point, therefore, to zero, the observer graduates his beam into hundredths and minor subdivisions. The graduation is then made in similar manner for carbonic acid, employing rider *r′* and battery I I. In practice, these graduations would be made before the instruments were placed in position, allowances being made for the depth and increased temperatures to which each balance is to go.

Thus adjusted, the instrument will act under the conditions named as follows:—

1. *Rising Barometer and no "Fire-Damp."* 2. *Falling Barometer and no "Fire-Damp."* 3. *Rising Barometer and "Fire-Damp."* 4. *Falling Barometer and "Fire Damp."*

Notes.—1. The percentage of carbonic acid exhaled from coal usually runs from 0·30 to 2·1 per cent. in fire-damp, varying in different mines, but practically constant in any one. There may be a sudden increase by an explosion, but ventilation would soon restore the normal condition. The quantity produced by the lamps and men is insignificant, since the ventilation necessary to keep the mine free from fire-damp sweeps away the carbonic acid from this source as fast as formed.

2. Should it be desirable to test for marsh gas only, balance 2 may be surrounded by an air-tight case, provided with a tube opened or shut at will by a mercury valve operated by an electromagnet controlled from the observing station. This tube would be opened for, say, five minutes. During that time the external gases would diffuse perfectly through the tube into the case, but both moisture and carbonic acid would be immediately absorbed by caustic potassa placed in D′. The tube would then be closed, and measurements taken, pure marsh gas being the standard. These tests would be made as often as desired, the observer having full control of the valves on all the instruments and operating all on one circuit.

3. While a separate circuit is shown for the right-hand or left-hand helices, it is practicable, by a simple device arranged by the inventor, to operate either helix at will from the observing station, and yet use but a single circuit.

4. With bulbs of 300 cubic inches capacity, a balance weighing to $\frac{1}{10}$th of a grain will give the percentage of marsh gas to $\frac{1}{3}$rd of 1 per cent. The bulbs weigh six ounces. This weight may be lessened 86 grains by filling them with pure hydrogen. A reading to $\frac{1}{3}$rd of 1 per cent. is close enough in practice.

5. The instrument is especially designed for use in goaves, where large accumulations of the gas are more liable to form. A decrease in atmospheric pressure forces it out in the workings, where it may be fired by a shot, a defective lamp, or other causes. It having been settled that the explosions supposed to be wholly due to coal dust depend on marsh gas in conjunction with the dust, the necessity for close watch upon even small percentages is obvious.

6. As marsh gas spreads with tolerable rapidity, one instrument will guard a considerable area, especially in a goaf where ventilation is neglected.

DYNAMO-ELECTRIC MACHINES.*

BY JOHN HOPKINSON, D.SC., F.R.S., AND EDWARD HOPKINSON, D.SC.

Omitting the inductive effects of the current in the armature itself, all the properties of a dynamo machine are most conveniently deduced from a statement of the relation between the magnetic field and the magnetising force required to produce that field. This relation given, it is easy to deduce what the result will be in all employments of the machine, also the result of varying the winding of the machine in armature or magnets. The magnetic field may be expressed algebraically as a function of the magnetising force, or more conveniently by a curve (*Proceedings* of the Institution of Mechanical Engineers, April, 1879, p. 246). Amongst the empirical formulæ which have been proposed to express the electromotive force of dynamo machines in terms of the currents around the magnets, we may mention that known as Fröhlich's, where $E = \frac{ac}{1 + bc}$, E being the electromotive force of the machine at a given speed, *c* the exciting current, and *a* and *b* constants. For some machines this hyberbola is said to express observed results fairly accurately. In our experience it does not sufficiently approximate to a straight line in the part of the curve near the origin, and gives too high results for large values of *c*.

One purpose of the present investigation is to give an approximately complete construction of the characteristic curve of a dynamo of given form from the ordinary laws of electro-magnetism and the known properties of iron. Let *n* be the number of convolutions on the magnets, *c* the current round the magnets, l_1 the mean length of the lines of force in the iron of the armature, A_1 the area of section of iron in the armature, l_2 the distance from iron of armature to iron of pole pieces, A_2 the area of the magnetic field in which the wires move corrected for its extension round the edge of the pole pieces, l_3 the total length of the magnet cores, A_3 the area of the magnet cores, l_4 the mean length of lines of force in the yoke connecting the magnet limbs in machines of the type on which we have principally experimented, A_4 the area of section of the yoke, l_5 the mean length of the lines of force in each pole piece, A_5 the mean area of section of pole piece, I the total induction through the armature, when no current passes in the armature, and νI the total induction in the magnet cores; and, finally, let the relation between the magnetic force (α) and induction (a) (*vide* Thomson, "Electrostatics and Magnetism," p. 397, and Maxwell, "Treatise on Electricity and Magnetism," Vol. II., p. 24) be represented by the equation $\alpha = f(a)$, then the characteristic curve is—

$$4\pi nc = l_1 f\left(\frac{I}{A_1}\right) + 2l_2 \frac{I}{A_2} + l_3 f\left(\frac{\nu I}{A_3}\right) + l_4 f\left(\frac{\nu I}{A_4}\right) + 2l_5 f\left(\frac{I_5}{A_5}\right).$$

If the relation between α and a be given in the form of a curve, this formula indicates at once a perfectly simple graphical construction for the characteristic. Taking the curve of magnetisation determined by one of us for wrought iron, and constructing a characteristic in this way, we have obtained a theoretical curve which agrees over a long range with the actual results of observation on a dynamo machine more closely than any empirical formula with which we are acquainted.

To determine ν, a wire was taken once round the middle of one magnet and connected to a ballistic galvanometer; a known current was then either suddenly passed round the magnets or short-circuited, the elongation of the galvanometer being noted. A similar observation was made with the same current, the galvanometer being connected to a single convolution of the armature in the plane of commutation. The ratio of the two elongations is the value of ν.

The distribution of the waste field $(\nu - 1)$ I was roughly ascertained in a similar method.

The currents in the fixed coils round the magnets are not the only magnetising forces applied in a dynamo machine. The currents in the moving coils of the armature have also their effect upon the resultant field. In well-constructed machines the effect of the latter is reduced to a minimum, but it can be by no means neglected. This introduces a second independent variable, viz., C, the current in the armature. The effect of the current in the armature depends upon the lead given to the brushes. Denote this by λ, which we may also regard as an independent variable, as it is subject to arbitrary adjustment.

If $I = F(4\pi nc)$ be the characteristic curve when no current passes through the armature, then

$$I + \frac{\nu - 1}{\nu} 4\lambda m C \frac{A_2}{l_2} = F\left(4\pi nc - \frac{4\lambda m C}{\nu}\right),$$

where *m* is the number of convolutions in the armature. Here

* Abstract of a Paper read before the Royal Society.

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we omit the comparatively unimportant portion of the magnetic force in the core of the armature and the pole pieces. From this formula it is not difficult to deduce a geometrical construction for the characteristic surface (*vide* "Practical Applications of Electricity," lectures delivered at the Institute of Civil Engineers, 1882-83, p. 98). The equation may be thus expressed in words, if λ be such that the coils at commutation embrace the whole or nearly the whole induction. The effect of the current in the armature upon the difference of potential between the brushes of any machine is the same as that of an addition to the resistance of the armature proportional to the lead of the brushes, and to the ratio of the waste field to the total field, combined with that of taking the main current $\frac{m\lambda}{\nu\pi}$ times round the magnets in a direction opposite to the current c. Many consequences can be deduced, of which we may notice the following :—In a series wound dynamo C is equal to c, and if c be increased beyond a certain point, I must attain a maximum and then diminish; this has been frequently observed. We now see that it depends upon the existence of a waste field. Secondly, let the coils of the magnets be entirely disconnected, and let λ be the negative; if the armature be short circuited through a small resistance and be run at a sufficient speed, a large current may be produced in the armature. This latter deduction we have verified by direct experiment.

The efficiency of the type of dynamo machine upon which the experiments before indicated have been made has been accurately determined by the device of coupling two similar machines, both mechanically and electrically, so that one should act as a generator of electricity, driving the other electrically, whilst the latter acted as a motor driving the former mechanically; the loss of power required to keep the whole combination in movement being determined by direct dynamometric measurement, and the power passing electrically from the one machine to the other being measured by ordinary electrical appliances.

The whole of the experiments were carried out at the works of Messrs. Mather and Platt, to whom we are indebted for the exceptional opportunities we have enjoyed of putting theoretical conclusions to the test of experiment on an engineering scale.

A CORRECTION.

By an oversight an article was inserted in our last issue under the heading of "New Voltmeter and Ammeter for Control in Working." The article inserted was merely an abstract, with translator's notes interpolated. The last paragraph, commencing "The lines of force" to the end have nothing to do with the abstract, and even if inserted the word "parallel" should in each case be read "perpendicular." In the last sentence the reference A and B refers to a figure similar to one in "Maxwell," Vol. 2, Fig. 18. If, however, the last paragraph be struck out, the remaining portion will refer to the instruments.—[ED. *E.*]

TELEPHONY IN AMERICA.

The following is an extract from the Bell Telephone Company's report for the year ended Dec. 31, 1885, read at Boston, at the annual meeting, on March 30, 1886 :—

The year ending Dec. 31, 1885, has not been marked by the increase of business of previous years; but although there has been a loss of subscribers in exchanges at certain points, on the whole the licensed companies have more than held their own, the total number of subscribers showing an increase of 2,969, and of telephones in use of 4,466 during the year. The comparative statistics which follow are substantially accurate; but, as usual, we are prevented from giving figures with the precision which would be possible if the entire telephone system were managed by us directly :—

Exchange Connections.

The estimated number of exchange connections daily in the United States is 746,517, or a total per year of 272,478,705. The number of calls per subscriber varies in different exchanges from 2 to 10 daily, the average throughout the United States being $5\frac{43}{100}$, as compared with $5\frac{18}{100}$, the number reported last year, an increase of about 5 per cent. The average cost to the subscriber varies—according to the size of the exchange and the character of the service—from 2 to 7 cents per connection.

Exchanges.

—	1883.	1884.	1885.	1886.	Dec. from 1885.	Incr. over 1885.
Exchanges	725	906	764	752	12	—
Branch offices............	345	419	481	432	40	—
Miles of wire on poles...	—	—	88,481	100,630	—	12,149
ditto on buildings...	—	—	11,886	10,049	1,837	—
ditto underground...	—	—	1,225	3,428	—	2,203
ditto submarine......	—	—	—	264	—	264
Total miles of wire......	68,571	85,896	101,592	114,371	—	12,779
Total circuits............	74,484	97,422	107,268	110,967	—	3,699
Total subscribers	97,028	123,625	134,601	137,570	—	2,969
Total *employés*	3,716	4,762	5,162	5,344	—	182

Underground Wires.

—	Miles of wire underground, 1885.	Miles of wire underground, 1886.	Increase over 1885.
Washington......	770	992	222
Chicago	—	760	760
New York	—	627	627
Pittsburgh	223	614	391
Boston	232	289	57
Brooklyn	—	134	134
Baltimore	—	11	11
Milwaukee	—	1	1
	1,225	3,428	2,203

Extra Territorial Lines.

—	Jan. 1, 1883.	Jan. 1, 1884.	Jan. 1, 1885.	Jan. 1, 1886.	Increase during 1885.
Number of lines............	247	598	826	931	105
Miles of pole lines.........	6,154	20,592	25,766	31,395	5,629
Miles of wire	13,653	29,359	35,631	42,461	6,820

Instruments.

—	Dec. 20, 1882.	Dec. 20, 1883.	Dec. 20, 1884.	Dec. 20, 1885.	Increase during the year.
In hands of licensees, under rentals	237,728	298,580	325,574	330,040	4,466

Extra-Territorial Business.

The average daily number of extra-territorial connections is 6,663, or total number per year of 2,431,995. The extra-territorial earnings, as reported, amounted to \$538,740.43, of which this company's share is \$72,677.28 cents, an increase over 1884 of \$5,411.63 cents.

Last year's statement included the connections between exchanges of the New York and New Jersey, and the Pacific Bell and Sunset Companies, on the receipts from which we receive no percentage. These do not appear this year, which will account for the apparent decrease in the number of connections.

The removal of open wires from house-tops to overhead cables and to underground conduits has continued, the progress in the latter respect being especially encouraging. The system must always be a mixed one, as the final distribution of the wires to the customers, and the method of reaching places where underground work would be too costly, must still be overhead; but we think that within a few years in all large cities the open wires will be placed in cables above or under ground to such an extent, at least so far as telephone companies are concerned, that the overhead wire nuisance will no longer be serious. In New York an amendment to the law which ordered all wires in New York city and Brooklyn under ground before last November was adopted, establishing a commission for each of these cities with power to supervise the execution of the law, and to arrange for placing the wires underground to such an extent as might be found practicable. In Brooklyn the commission has permitted the wire companies to begin their work, and 134 miles of underground wire have been placed there by the Telephone Company. In New York the Metropolitan Company, in August, 1885, filed with the commission the necessary plans and statements for an underground system, and applied for permission to prosecute the work, but so far without success, and the work in that city is at present at a standstill.

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THE ELECTRICIAN.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

TO CORRESPONDENTS.

All communications to be addressed to 1, Salisbury-court, Fleet-street, E.C. Those relating to Subscriptions, Advertisements, back numbers of the Paper, and so forth, should be addressed to the Publisher; and those relating to Articles, Correspondence, or Notes, to the Editor.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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With our next number a Supplement will be issued (Gratis), containing the Index to Vol. XVI. This Supplement should be received with every copy of the paper. Complaints of non-receipt should be forwarded to the Manager.

THE ATLANTIC CABLE COMPANIES.

The few remarks which we appended to our last week's announcement that a war of cable rates was about to be commenced between the four "pool" companies and the refractory "COMMERCIAL" Company showed that our sympathies were entirely on the side of the former; and on a closer investigation of the circumstances we have discovered no grounds for qualifying our verdict, but rather have been confirmed in the opinion that sooner or later some extreme measure of the kind proposed is inevitable, and that if no compromise is arrived at between now and the 5th of May the present is a very favourable time for beginning hostilities. Deplorable as are usually the consequences of a war of rates, there are some contingencies even more deplorable—the ruin of all the parties concerned. In self defence, and as a last resort, the stronger of two combatants may quite justifiably put forth his whole force to crush his opponent rather than tamely submit to being starved into a condition of feebleness from which there would be no recovery except on terms dictated by the weaker foe. But having declared war, it should be as cruel, as decisive, and as sharp as the assailants can make it; and we are glad to see that this is the course decided upon. A reduction from one shilling and eightpence a word to sixpence a word would in ordinary circumstances be suicidal, and under no conditions can it be beneficial; but as a precautionary or retaliatory measure the more drastic it is the more certain is it to be quickly over and done with.

To be effectual it need not be ruinous to the people against whom the reduction is aimed. They have only to do what their predecessors have done, and what in the nature of things competitive cable companies must always do to save themselves from extinction, namely to abandon competition and give their minds to legitimate business. The Bennett-Mackay —or more correctly, since Mr. BENNETT took a back seat, the Mackay-Bennett—Cables were laid with the ostensible object of reducing the rates of the existing cable lines. There were more than enough of them to deal with the actual or prospective traffic; and the rate of two shillings a word was not returning a very luxurious dividend to the original cable company, or to any of its imitators, whom stress of competition had compelled it to buy up, or to share with them a common purse. The rival cable did succeed in reducing the rate by fourpence a word, with the result that the aggregate traffic, divided among five companies instead of four, and at rates reduced so as to tell seriously upon receipts, but not to materially stimulate business, has inflicted a heavy pecuniary loss upon four of the competitors, and probably also upon the fifth. We may suspect that the ostensible object of the Mackay-Bennett's "Commercial" venture was not its real object. But be that as it may, those two astute speculators may be credited with having counted among their risks that of a combination hostile to their existence as independent rivals. They cannot complain of harsh or unfair treatment, even if the very worst befall them; they set the example of applying purely business considerations to their own speculation, and they must not expect to obtain exemption for themselves on mere sentimental grounds. The COMMERCIAL Company was a reckless and superfluous competitor in the field of Atlantic telegraphy; and the fact that it was not the first offender only makes its intrusion the more inexcusable and intolerable.

We are not precisely informed as to the terms on which the ANGLO-AMERICAN, the DIRECT UNITED STATES, the WESTERN UNION, and the FRENCH ATLANTIC Companies have invited the COMMERCIAL to join their friendly arrangement; but we may take it that it is on a joint purse basis common to all the rest. Down to the moment of writing this the COMMERCIAL Company rejects these overtures, counting, perhaps, on some special advantages which it claims to enjoy in possessing a direct sea route. Possibly, also, its concession from the French Government, conditional, we believe, upon the rates being not higher than two francs a word, may have some weight, though, as their main cables are forked on British soil, the French agreement need prove no insurmountable obstacle to an understanding with the English Companies. But whatever the immediate cause of hesitation, we have little doubt that the pinch of necessity will soon disclose a way to get out of the difficulty. And we make no scruple in repeating that the pinch should be as painful as the attacking forces can anyhow afford to inflict. The sixpenny rate is to extend not merely to the cable lines but to all the area over which the COMMERCIAL have influence on land, and to every place to which it can possibly extend. The "BALTIMORE and OHIO RAILWAY" district, the "POSTAL TELEGRAPH," and the "BANKERS' and MERCHANTS'" lines, all of which are feeders of the COMMERCIAL Cable on the side of the United States, are to be embraced by the war tariffs; and, in short, the COMMERCIAL Company are to be compelled to accept their own particular

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traffic at a loss, or to see it slip out of their hands altogether, whilst the other Companies will at least reap the advantage of higher land rates to the larger area over which their influence prevails.

Such is the view we naturally take of the situation on this side the water. In New York it seems they take quite another. The representatives of the COMMERCIAL Cable, it is reported, have hit upon the novel idea of appealing to the public to help them in the coming struggle. We call it novel, because although such appeals are not wholly unknown, they have never in our recollection been made by the very party which has the least claim to be listened to. Despite the obvious inconsistency of the thing, American business men are being invited on large placards to "rally round" the COMMERCIAL Company, to resist monopoly, and sustain cheap rates. We are quite sure of their disposition to support cheap rates, and for that very reason they will patronise the sixpenny cables so long as their custom is accepted at the price. As to monopoly, the public trouble themselves extremely little with abstract principles; and when it comes to a question of "rallying round," that cry is just as good and just as futile for an old company as for the new. Nobody rallied round the ANGLO, or the DIRECT, or the WESTERN UNION when the COMMERCIAL started to cut down their rates; and either the Mackay-Bennett people must be more simple, or the American people more self-denying than we take them to be, if an appeal for help at high prices is more effectual from one cable than when it came from three or four. The proprietors of the COMMERCIAL Cable, we fancy, have yet to learn the lesson which they have made it their particular boast to teach, namely, that customers will buy at the cheapest store, no matter what becomes of the opposition storekeeper. Yesterday the Company issued a circular, which we print elsewhere, reducing their rate to 1s., and asking their patrons to make a temporary sacrifice, "on the assurance that if we are vigorously backed up now the tariff shall return to the original figure—viz., 1s. 8d." The wording of this document is sufficiently singular; but the meaning of it is simply absurd.

CORRESPONDENCE.

PROFESSOR HUGHES ON HIS CRITICS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have noticed several criticisms in your valuable journal upon my paper on "self-induction," which I believe require a few remarks in reply.

The criticisms may be divided into three classes.

First—Prof. H. F. Weber shows that the method which I employed admits of numerous errors, and consequently infers that the results which I have announced are due to an "incorrect interpretation."

Second—Mr. Oliver Heaviside points out that upon a close examination it will be found that all the effects which I have described are well known to mathematicians, and consequently old.

Third—Mr. Willoughby Smith points out that the results which I have announced are contrary to theory and practice, and demonstrates that he is unable to obtain any difference even between iron and copper.

I must say that I am unable to agree with these opposing views, for if we assume with Mr. Heaviside that all my results are contained in some mathematical formula of which I am unaware, then the mathematicians ought to feel extremely grateful for the experimental proof which I have furnished them; if, on the other hand, we agree with Mr. Willoughby Smith, then the formula and my results should at once be abandoned as experimentally untrue.

Prof. Weber's objection is more serious, and I fully admit that it is possible to make very serious errors if the sonometer is not calibrated, or if we do not appreciate the errors that can be easily introduced. I feel sure that Prof. Weber could have seen how such errors could have been avoided, and this even by several means that I have indicated, such as making comparative tests between wires of the same length and resistance, so that no change took place in the bridge adjustment except that due to the differential results.

The only question which I consider important is, Are the effects which I announced true physical effects due to nature or form of the conductor, or are they simply due to some peculiarity of the method which I employed? To answer this I have constructed an instrument based upon an entirely different method, one of extreme simplicity, and one which does not allow of any possible error.

I propose to publish a description of this instrument (together with the results obtained) during the coming month, when I hope that its demonstrations will prove clearly all that I have said as to the influence of the form as well as the nature of the conductor upon its self-induction.—Yours, &c.,

D. E. HUGHES.

(Translation.)

HYPNOTIC EFFECT OF THE ELECTRICAL CURRENT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have the honour to address you a brief reply to the question propounded by one of your correspondents.

The efficacy of the treatment of insomnia by electricity is one of the best-established facts of electro-therapeutics. The voltaic current, the faradaic current, or even static electricity may be employed. I will confine myself to describing in detail the voltaic process, which is the readiest and the most certain. I will assume we have the ordinary medical battery, *i.e.*, one composed of Daniell or Leclanché elements, provided, amongst other accessories, with a collecting-switch, allowing of the gradual introduction into the circuit of the requisite number of elements without interrupting the current, and with a galvanometer graduated in fractions of an ampere. The electrodes are of the ordinary pad form, carbon or metal covered with cloth or with chamois leather. The negative electrode should be about 7 centimetres, and the positive 5 centimetres in diameter. After having soaked them in ordinary water, they are applied to the two temples, behind and above the eyebrow, with a moderate pressure. The negative pad may be entrusted to an assistant or to the patient himself; the positive is held by the operator. After waiting for a minute to allow the epidermis to become moistened the switch is moved so as to gradually insert the elements into the circuit. At the same time the galvanometer is watched, and as soon as it indicates 15 ten-thousandths of an ampere the movement of the switch is discontinued and the current is allowed to act. Ordinarily, the deflection of the needle slowly increases; and if the rate of increase be too rapid, or, in any case, as soon as it approaches 30 ten-thousandths, the number of elements must be diminished. After the current, maintained within these limits, has passed for two minutes, it must be interrupted. This is the delicate portion of the operation; the interruption must be gradual, and the positive electrode must be removed before the other. The best means formerly, unless I am mistaken, indicated by (?) Ziemssen is to slide the positive pad, whilst maintaining the pressure, up to the roots of the hair, and finally to pass it on to the hair. During this manipulation the needle returns towards zero; and, at the end of it, the current has been interrupted without the production of any shock. In spite of these precautions it is difficult, in the case of certain patients, to avoid certain luminous sensations (phosphines electriques), and a certain amount of giddiness. These phenomena are absolutely without danger in the case of the current here employed. It often happens that I purposely produce them; since I have observed that when they are produced success is more certain. The only reason for avoiding them is that with very excitable or timid patients the resulting emotions may

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augment their nervousness and cause them to be afraid of the treatment.

I have not mentioned the number of elements to be used, since this depends upon the (very variable) electrical resistance of the patients. The galvanometric indication is alone of importance, and is sufficient for the purpose in view.

By means of this very simple treatment, which I have employed hundreds of times, the most stubborn cases of insomnia have, almost without exception, been overcome. Ordinarily, this is what occurs. If the galvanisation has taken place in the morning the patient experiences no particular sensation for the remainder of the day, only in some cases a little sleepiness, which increases towards night; but next day he is surprised to find that he has slept for eight or nine hours without interruption. The effect of a single sitting continues, in diminishing degree, during two or three days, after which the application must be repeated.

For the most part, a few sittings are sufficient to effect a cure. Should the first application not have a very marked effect, the process must be modified. Thus, the positive electrode may be applied to the forehead and the other to the back of the neck; or the very efficacious method of applying the positive electrode successively to the eyes may be adopted. In the last case the current must be weaker than usual (from 8 to 15 ten-thousandths), and the application shorter (one minute for each eye).

Another simple and harmless method consists in applying to and retaining upon the temples plates of tin covered with chamois leather, serving as electrodes to one or two fluid elements of Trouvé. The application should last for two hours or even much longer. The battery is placed in the patient's pocket, or, should he be in bed, beneath his pillow.

If, in an exceptional case, none of these methods succeeds, electricity need not on that account be given up. Some of the numerous processes of faradisation, or of applying statical electricity may be, and, in fact, sometimes are, more efficacious.

It must be understood that what is here referred to is insomnia properly so called, and not the sleeplessness occasioned by pain in any portion of the body. I repeat that, by means of the processes which I have just described, I have restored sleep to patients who declared that they had not slept for months or years, and who took, without effect, enormous doses of morphia or chloral.

I called the attention of medical men to these facts in a note published ten years ago in the *Journal des Connaissances Médicales*. But I am far from wishing that I should be thought the inventor of the process. It was, and it still is, more or less indicated in works on electro-therapeutics. Nevertheless it seems to me that it is not at the present time sufficiently known and practised.—Receive, &c.

(Signed) DR. R. VIGOUREUX,
Chief of the Electro-Therapeutic Service
Paris, 24th April, 1886. at the Salpêtrière.

LECTURE APPARATUS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you allow me through the medium of your columns to call the attention of instrument makers to a much required improvement in a simple lecture apparatus?

The distribution of electricity, when in equilibrium, upon the surface of conductors is usually experimentally shown by means of a metal sphere mounted upon an insulating stand, and which can be enclosed within a hollow sphere formed of two metal hemispheres to which insulating handles are attached. The internal sphere appears to be invariably made of such a size that the two hemispheres only just contain it, and the ordinary text books all figure the apparatus in this way. The result is that it is almost impossible to withdraw the hemispheres without allowing them to touch the inner sphere after separation, which makes it most unsatisfactory for a lecture experiment. The difficulty is easily obviated by making the diameter of the internal sphere considerably smaller than that of the hemispheres, which makes the experiment perfectly easy and certain, and, of course, it does not affect its principle in any way, for it is clearly unnecessary to have many points of contact between the two conducting spheres.

It is an improvement in the neatness of the experiment to have semi-circular portions of metal filed away from the hemispheres so that the internal sphere can be completely enclosed by them, with the exception of the circular opening so formed in the external sphere, and which is required in order to allow the insulating stem of the inner sphere to pass through the outer one.—Yours, &c. G. W. VON TUNZELMANN.

THE TELEPHONE.—A CHEEKY QUESTION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: After reading several telephone cases, and seeing the wonderful area covered by certain patents, I am getting seriously uneasy in my mind whether I am not myself an infringement.

The other day, when inspecting the leads of an alternating circuit, I touched a badly insulated joint, and made a remark suitable to the occasion. What that remark was is of no consequence, but three friends heard it—at a distance. They assure me that the articulation was most distinct and very loud, and are unanimous in the opinion that it was due solely to the passage of an undulatory current through my body, as they are certain that I should never—no, never!—have made that remark of my own volition.

Further, I have taken the opinion of experts, and they all agree that the cheek is a diaphragm necessary to perfect articulation. That this is so is evident from the fact that if the cheek could be taken out of a telephone company there would be silence, or at most a confused grumbling sound, instead of loud articulation about patent rights. The experiment is a difficult one, and has never yet been properly carried out.

Now, what I want to know is this:—Can I be legally described as "an apparatus with a diaphragm or diaphragms which, when actuated by the passage of an undulatory current of electricity, produces and transmits to a distance articulate speech?" Because, if so, considering that I was manufactured without the license and consent of any telephone company, I think it would be advisable to "git" before an injunction is obtained against me and an order of the Court for my destruction.—Yours, &c., D.

Feast of St. Lubbock, 1886.

RESISTANCE COILS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The method of altering the bridge to make a B.A.U. box measure illegal ohms was mentioned in a letter to you of March 7th, 1885. It was also suggested that the Congress might go below, but alas! they are not gone.—Yours, &c.,

Chelmsford. JAS. SWINBURNE.

NEW EXPERIMENTS ON ELECTRICITY, HEAT, AND LIGHT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In my letter to you of the 1st curt., I produced experimental proof that electricity is a component part of the substance which we call ozone, and I broached the opinion that the flash of light seen by MM. Hautefeuille and Chappuis in the glass tube must have been the result of the union of a portion of the extra heat with the electricity which had formed a component part of the ozone prior to the ozone's decomposition, which caused the explosion. To determine the connection between, or rather the relative positions of, electricity and heat, I made the following experiments:—

I have a Geissler vacuum tube of the shape of the letter V, each leg of which measures 7½in. in length, and the outside diameter of it is ¾in. The platinum terminals being at the upper ends of the letter V, I adjusted this tube so that a powerful current of electricity passed through it from a

Ruhmkorff coil. I noted the amount of light produced within the tube while it was thus in the atmosphere of the room, at a temperature of + 67° F. I then had it placed in a freezing mixture of ice and salt, at a temperature of + 5° F. In this position the light within the tube was greatly diminished. I then had the same tube, with the same arrangement of coil, immersed in boiling water. Immediately a wonderful effect was produced. There was a greatly increased amount of light within the tube; a brilliant blueish flame filled both legs of the tube, and also striæ appeared of a very marked kind. As the latter never appeared in the tube when it was not in the boiling water, this leads to the conclusion that the striæ are produced by the increments of heat passing through the glass into the interior of the tube.

These experiments establish that the light produced in the tube which MM. Hautefeuille and Chappuis saw must have been the result of the union of the heat and electricity within the tube; and, further, these experiments lead to the conclusion that if we could place the V Geissler tube or an incandescent electric lamp in an atmosphere void of heat, no light would be seen in them, although a powerful current of electricity were passed through them.—Yours, &c.,

8, Merchiston-park, JAMES JOHNSTONE.
Edinburgh, 27th April, 1886.

DOUBLE CUT-OUTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In *The Electrician* of the 16th we notice an illustration of a cut-out which is said to have been designed by Messrs.

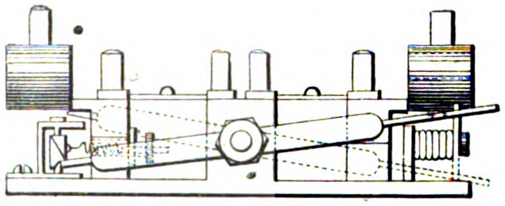


FIG. 1.

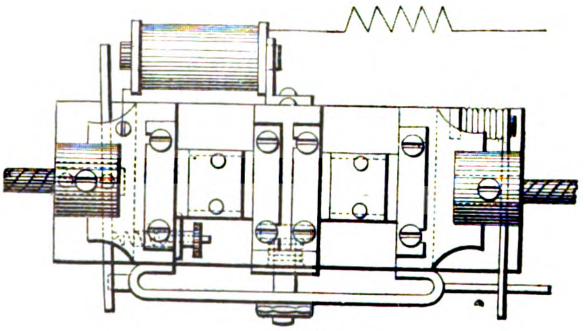


FIG. 2.

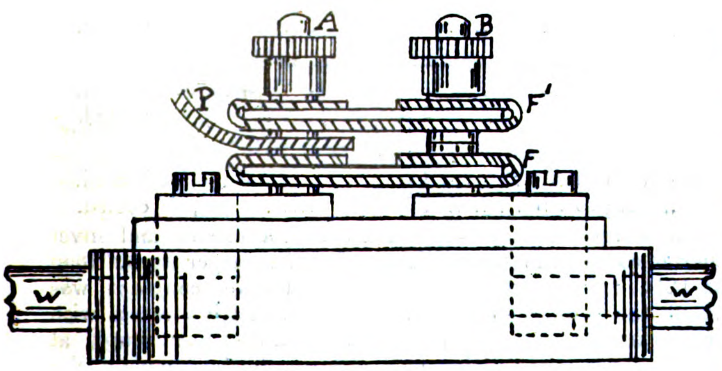


FIG. 3.

Baily and Grundy, "to remedy a defect in the older forms." We are sure these gentlemen are not acquainted with the early forms of the Hedges duplex cut-out, such as were shown at the Crystal Palace Exhibition, or they would not have claimed Mr. Hedges' original pattern, which has been superseded by the improved duplex form we now make, and which is more compact. We have supplied hundreds of these, and have lately designed a self-acting arrangement, so that the spare foil is automatically substituted for the one melted. The accompanying illustrations (Figs. 1 and 2) will render this easily understood; the switching lever is tripped by the action of a small electro-magnet, wound with fine wire, which is placed as a shunt with the line. Another arrangement, where eyelet foils are used, is shown by Fig. 3; the spare foil marked F_1 is placed on the top of the working one F, and is brought into action by withdrawing the paper insulating washer B, which then allows the current to pass through F_1.—Yours, &c.,

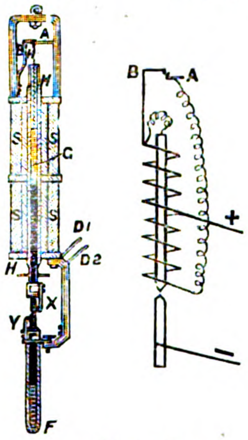
WILLIAM GRANGER, Manager of the Globe Electrical and Engineering Company.

20, Dartmouth-street, Westminster, S.W.,
April 21, 1886.

AN ARC LAMP FOR SMALL CURRENTS.

The Scharn-Weber lamp, a longitudinal section of which is shown in Fig 1, according to the *Centralblatt für Electrotechnik*, acts very well. For the regulation of the distance between the carbons three agents are employed—elasticity, gravity, and electro-magnetic attraction. The first is used only with the lower carbon, which a spiral spring gradually allows to rise as its weight decreases. The upper carbon is inserted in an iron tube, H, and is pressed down by a weight, G. This tube acts as the core of a solenoid, S. When the circuit is open the upper carbon rests on the under one. When the circuit is closed the tube, and with it the carbon, is so far drawn into the solenoid as its own weight and the above-mentioned weight (which rests on it) allow. Thus the arc is formed. As the carbon burns away the resistance becomes greater, and the current in the solenoid falls off, since it is in the same circuit, the attraction decreases and gravity acts and lowers the carbon till equilibrium is again restored. The course of the current can be seen from Fig. 2.

FIG. 1. FIG. 2.



Scharn-Weber Lamp.

If one lamp alone is in circuit its solenoid is simple; but if several lamps are in the same circuit each has a different coil. The throwing of the lamp out of circuit when the carbon is burnt down to a certain point is effected by a contrivance situated in its upper part. The weight G hangs by a chain to the spring A, which is opposite to another spring, B. The two springs press their points against each other. If the carbon is so far burnt away that the chain is stretched, the spring A is drawn down, and its point passes under that of the spring B, and the latter, released from the pressure of A, springs forward. The under part of B is covered with ebonite, so that the circuit through A and B is broken by this action. A novelty in these lamps is the incombustible holders of the carbons, which are pieces of osmium embedded in platiniridium.

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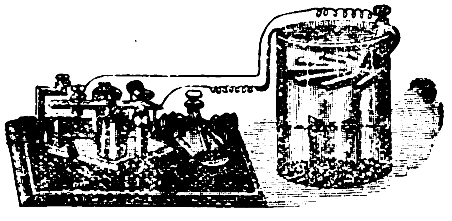
THE DIAMOND LEARNER'S TELEGRAPH INSTRUMENT.

The leading feature of the instrument here shown consists in so forming the sounder, anvil, and key that they have a diamond-shaped cross-section, and in so making the base of the sounder and of the anvil that when set up the two form a diamond outline. The magnets of the sounder are enclosed in metallic cases, and the various metallic portions of the instrument can be made to present the appearance of either gold, bronze, or brass. The black baseboard is of wood.



The Diamond Learner's Telegraph Instrument.

This instrument—designed by the Novelty Electric Company, of 5th and Locusts-streets, Philadelphia, Pa.— presents a unique and attractive appearance.—*Electrical World.*

ON THE PELTIER EFFECT AT DIFFERENT TEMPERATURES.*

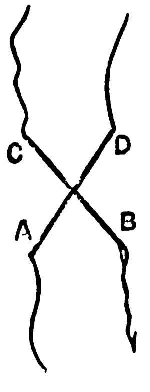
BY G. GORE, LL.D., F.R.S.

In order to examine this question I made the following experiments :—

A current of ·10 ampere was passed, during five minutes, through a thermo-electric pile, composed of thirty-six pairs of bismuth and antimony, at a uniform temperature of 8° C. The current was then stopped, and the terminals of the pile at once connected with an astatic galvanometer of 100 ohms resistance—the needles gave a swing of 8 degrees. The pile was then heated in a hot-water jacketed chamber to a uniform temperature of 65° C., and the experiment exactly repeated with the current of its original strength ; the needles now gave a swing of 17 degrees. These experiments were again exactly repeated, but with the pile at 9° C. and 85° C. ; the deflections were 8 degrees at 9° C. and 20 at 85° C.

These results indicate that the difference of temperature produced at and near the two junctions of a bismuth and antimony thermo-couple, by the passage of an electric current through them, is more than twice as great at 85° C. as at 8° C. As the amount of resistance of the galvanometer was large in comparison with that of the pile, the increased strength of current was due to increase of electromotive force.

In order to examine the amount of Peltier effect produced



at the two junctions of the pile separately, a current of ·2 ampere was passed, during about twenty seconds, from A to B, through a cross composed of two wires ; A D being of iron, ·5 millim. diameter, and B C of German silver, ·4 millim. diameter, whilst their opposite ends, C, D, were attached to a galvanometer, of about 2·0 ohms' resistance, by means of slender wires of copper.

With the entire cross and the adjoining portions of its conducting wires at 10° C., on passing the current from iron through the junction to German silver, a deflection of 3 degrees was produced, showing that the junction was heated ; and on passing it from German silver to iron, the deflection was 2 degrees in the same direction, showing that the junction was again heated, but in a less degree. These results were obtained several times. On repeating these experiments carefully in a similar manner, but with the cross and its attachments at 90° C., the current from iron through the junction to German silver produced a deflection of 4 degrees, indicating heat at the junction ; and on passing it from German silver to iron, the deflection was 2 degrees in the same direction, the junction being again heated.

These results show—1st, that with a thermo-couple composed of iron and German silver a current of uniform strength, passed from iron to German silver, evolved more heat than when passed in the opposite direction, whether the pile was at 10° C., or 90° C. 2nd, that when the current was passed from iron to German silver, it evolved more heat at and near the junction when the couple was at 90° C. than when it was at 10° C. And 3rd, that when it was passed from German silver to iron the amounts of heat evolved were about the same when the couple was at 90° as when it was at 10° C.

With the same strength of current, and a cross formed of bismuth and antimony, with the cross and its connections at 12° C., on passing the current from the bismuth through the junction to the antimony, a deflection of 8 degrees was produced, showing that the junction was cooled ; and on passing it in the opposite direction, the deflection was 8 degrees in the opposite direction, showing a heating effect. With the cross, &c., at 93° C., passing the current from the bismuth through the junction to the antimony produced a deflection of 10 degrees and a cooling effect ; and passing it in an opposite direction produced a deflection of 10 degrees and a heating effect.

From these results it appears that the Peltier effect, both of heating and cooling, with a thermo couple of bismuth and antimony, was considerably larger at 93° than at 12° C. Also that the amounts of heating and cooling effect were about equal, whether the couple was at 12° or 93°C.

Similar experiments were made with a cross formed of bismuth and silver, and with one composed of antimony and silver, the silver wire being ·5 millim. diameter, with the same strength of current as before. The results were as follows (the direction of current given in each case is that through the junction) :—

Direction of Current.	Deflection.	Thermal Effect.
Bismuth and Silver at 12°C.		
From Bi to Ag	2·0	...... Junction cooled.
„ Ag to Bi	2·0 to 2·5	„ heated.
Bismuth and Silver at 92° C.		
From Bi to Ag	3·0	...... Junction cooled.
„ Ag to Bi	3·0	...... „ heated.
Antimony and Silver at 12° C.		
From Sb to Ag	1·5	...... Junction heated.
„ Ag to Sb	1·5	...... „ cooled.
Antimony and Silver at 95° C.		
From Sb to Ag	1·5	...... Junction heated.
„ Ag to Sb	1·5	...... „ cooled.

These results show—1st. That with a bismuth and silver thermo-couple, the total Peltier effect was larger at 92° than at 12° C. ; 2nd, with an antimony and silver couple it was about the same at 95° as at 12° C. ; 3rd, that it was less with an antimony-silver than with a bismuth-silver couple at each temperature ; 4th, with a bismuth-silver couple the heating effect at 12° C. was somewhat greater than the cooling one, and at 92° C. the heating and cooling effects were about equal ; and 5th, that with an antimony-silver pair the heating and cooling effects both at 12° and 95° C. were all about alike.

* Read before the Birmingham Philosophical Society, February 11, 1886. From the *Phil. Mag.* for April.

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With the couples formed of bismuth antimony, iron-German-silver, and bismuth-silver, the total Peltier effect was greater in each case at the higher temperature than at the lower one, but with the antimony-silver one, the effects at the two temperatures were about equal.

All the results were probably affected to some extent by the influence of "electric convection of heat."

The whole of the results obtained (after making due allowance for differences in the specimens of medals employed by different experimentalists) agree with the thermo-electric diagram given in the manual on "Heat," by P. G. Tait.

ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 478.)

Theories which are founded on dynamical considerations and which take into account the action of the dielectric.

In the theories we have hitherto considered, the influence of the medium which exists between the currents has been left altogether out of account. In the theories which we shall now proceed to discuss the influence of this medium is taken into consideration. This is, perhaps, the most important step that has ever been made in the theory of electricity, though from a practical point of view it is comparatively of little importance; in fact, for practical purposes almost any one of the preceding theories will satisfy every requirement.

Faraday was the first to look upon the dielectric as an important agent in electrical phenomena; he was led to this by his desire to get rid, as far as possible, of the idea of action at a distance, which was so prevalent in his time, but to which his researches have given the death-blow. In his "Experimental Researches," § 1164, speaking of electrostatic induction, he says, "I was led to suspect that common induction itself was in all cases an action of contiguous particles, and that electrical action at a distance (*i.e.*, ordinary inductive action) never occurred except through the influence of surrounding matter." And later on he gives his views as to the nature of the effect in the medium; in § 1298 of the "Researches" he says, "Induction appears to consist in a certain polarised state of the particles into which they are thrown by the electrified body sustaining the action, the particles assuming positive and negative points or parts, which are symmetrically arranged with respect to each other and the inducting surfaces or particles. The state must be a forced one, for it is originated and sustained only by force, and sinks to the normal or quiescent state when that force is removed. It can be continued only in insulators by the same portion of electricity, because they only can retain this state of the particles." He gives an experimental illustration of his view in § 1350. He says, "As an illustration of the condition of the polarised particles in a dielectric under induction I may describe an experiment. Put in a glass vessel some clear rectified oil of turpentine, and introduce two wires passing through glass tubes, when they coincide with the surface of the fluid and terminating in balls or points. Cut some very clean dry white silk into small particles, and put these also into the liquid; then electrify one of the wires by an ordinary machine and discharge by the other. The silk will immediately gather from all parts of the liquid and form a band of particles reaching from wire to wire, and if touched by a glass rod will show considerable tenacity; yet the moment the supply of electricity ceases the band will fall away and disappear by the dispersion of its parts. The conduction by the silk is in this case very small, and after the best examination I could give to the effects, the impression on my mind is that the adhesion of the whole is due to the polarity which each filament acquires, exactly as the particles of iron between the poles of a horseshoe magnet are held together in one mass by a similar disposition of forces. The particles of silk therefore represent to me the condition of the molecules of the dielectric itself, which I assume to be polar, just as that of the silk is. In all cases of conductive discharge the contiguous polarised particles of the body are able to effect a neutralisation of their forces with greater or less facility, as the silk does also in a very slight degree. Further we are not able to carry the parallel, except in imagination; but if we could divide each particle of silk into two halves, and let each half travel until it met and united with the next half in an opposite state, it would then exert its carrying power (1307), and so far represent electrolytic discharge."

And it is not only in statical electricity that Faraday recognised the importance of the dielectric. When he is discussing his discovery of the induction of currents, which he ascribes to the assumption of what he called the electrotonic state by the body in which induced currents are developed, he says, § 73, "It may even exist in non-conductors," that is, that there is an electromotive force acting on the surrounding dielectric due to the variation in the primary current. Again, in § 1661, he says, "Now though we perceive the effects only in that portion of matter which, being in the neighbourhood, has conducting properties, yet hypothetically it is probable that the non-conducting matter has also its relations to, and is affected by, the disturbing causes, though we have not yet discovered them. Again and again the relation of conductors and non-conductors has been shown to be one, not of opposition in kind, but only in degree (1334, 1603); and therefore for this, as well as for other reasons, it is probable that what will affect a conductor will affect an insulator also, producing, perhaps, what may deserve the term of the electrotonic state (60, 242, 1114)." And though he was unable to detect these effects experimentally, the following paragraph (1728) shows that his belief in their existence was not shaken: "But then it may be asked, What is the relation of the properties of insulating bodies, such as air, sulphur, or lac, when they intervene in the line of magnetic action? The answer to this is at present merely conjectural. I have long thought there must be a particular condition of such bodies, corresponding to the state which causes currents in metals and other conductors (26, 53, 191, 201, 213); and considering that the bodies are insulators, one could expect that state to be one of tension. I have, by rotating non-conducting bodies near magnetic poles, and poles near them, and also by causing powerful electric currents to be suddenly formed and to cease around and about insulators in various directions, endeavoured to make some such state sensible, but have not succeeded. Nevertheless as any such state must be of exceedingly low intensity, because of the feeble intensity of the currents which are used to induce it, it may well be that the state may exist, and may be discoverable by some more expert experimentalist, though I have not been able to make it sensible."

Maxwell was the first to express Faraday's ideas in mathematical language. In his papers on "Physical Line of Force" in the *Philosophical Magazine* for March, April, May, 1861, and January, February, 1862, he develops a theory of electricity according to which the energy of the electro-magnetic field resides in the dielectric as well as in the conductors; later, in the *Philosophical Transactions* for 1865, he greatly extended Faraday's ideas as well as put them into definite mathematical language, and this without reference to any special theory of the mechanism which produces electrical phenomena. We shall devote some time to discussing Maxwell's theory, as it is freer from serious objections than any other, while at the same time it covers a much wider ground.

We shall begin by referring to Maxwell's view of the state of the dielectric in the electric field. Maxwell supposes that the dielectric is changed, and perhaps the clearest way of describing this change is that of Faraday in the extract already quoted. Maxwell's nomenclature as to this change is a little unfortunate; instead of speaking, like Faraday, of the polarisation of the dielectric, he speaks of the change as consisting of an electric displacement, which in isotropic media is in the direction of the electromotive force. Mathematically the two things are identical; we may either say of a wire that it is negatively electrified at one end A, and positively at the other end B, or else that there is a displacement of positive electricity from A to B, so that there is an excess of positive electricity at B and a deficiency at A. But though the words in a mathematical sense are identical, still the word displacement seems to connote special qualities which limit the generality of the concep-

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tion in an undesirable way; the word displacement seems to imply motion in the direction of displacement, while polarisation only implies that there is a vector change of some kind in the dielectric. The condition of the dielectric is quite analogous to the state of a piece of soft iron placed in a magnetic field. The polarisation or displacement is in isotropic media in the direction of the electromotive force and proportional to it, just as the magnetic induction in isotropic media is in the direction of the magnetic force and proportional to it. It was this proportionality, combined with the fact that as soon as the electromotive force is removed the dielectric springs back, as it were, to its original state, that led Maxwell to use the word displacement. He looked on the case as analogous to that of an elastic solid, which springs back to its original position when the external force is removed, and in which the displacement is proportional to the impressed force. To avoid any unnecessary definiteness we shall use the term dielectric polarisation instead of electric displacement. Thus, according to this view, the dielectric in the electric field is polarised. This polarisation means change of structure of some kind, and to produce this change of structure work is required. The energy in the polarised dielectric will be greater than the energy when it was unpolarised, for if the energy were less the dielectric would go into the polarised condition of itself, without the application of any external forces.

It is rather difficult to see what is meant in Maxwell's theory by the phrase "quantity of electricity." According to the old two-fluid theory an electrified body was supposed to contain a certain quantity of something called electricity, rules were given for measuring this quantity, and the phrase "quantity of electricity" meant something quite definite. In Maxwell's theory, where everything is referred to the dielectric, the meaning of the phrase is not so obvious. We can, however, arrive at some idea of what is meant by the consideration of what are called "tubes of force." Let us suppose at first that the dielectric is air. A line of force is a line whose direction at any point coincides with the direction of the electromotive force at that point, so that we may conceive the electric field to be filled with lines of force. If we consider the lines of force passing through some small closed curve, they will form a tube, and such a tube is called a tube of force; and if the dimensions of the tube are such that the product of the cross section at any point and the electromotive force at that point is constant and equal to 4π, the tube is called a unit tube. We may thus conceive space to be filled with unit tubes of forces. Since the electromotive force inside a conductor vanishes these tubes will end at the surface of a conductor, and the quantity of electricity on the conductor will be equal to the excess of the number of lines of force which leave the conductor over those which enter it. A tube is said to leave the conductor when the direction of the electromotive force is along the normal drawn outwards, and to enter it when the direction of the electromotive force is along the normal drawn inwards. As the conductor moves about it may be supposed to carry the tubes of force along with it, so that the number of tubes which end on the conductor remains constant. This way of looking at electrification is quite satisfactory as long as we keep to one dielectric air; when we have to consider different dielectrics it requires modification, because the electromotive force changes abruptly as we pass from one dielectric into another, so that a tube which was a unit tube in one dielectric is not so in another. It is easy, however, to extend the definition of unit tubes so as to meet this difficulty; for if the tubes pass from one dielectric, A, into another, B, the ratio of the product of the cross section and electromotive force is constant for all the tubes, and depends only on the nature of the dielectrics; this ratio is the ratio of the specific inductive capacities in B and A. Air is taken as the standard dielectric, and the specific inductive capacity of another dielectric, A, is the ratio of the product of the electromotive force and cross section of a tube in air to the product of the same quantities for the same tube in the dielectric A. Thus, if we amend our definition and say that a circuit tube is one such that the product of the cross section, the electromotive force, and the specific inductive capacity of the medium in which the cross section is situated is equal to 4π, then the quantity of electricity on a conductor is equal to the excess of the number of unit tubes which leave the conductor over the number of those which enter it. In this way we get an idea of what is meant by "quantity of electricity" in Maxwell's theory. Maxwell accounts for the forces observed between electrified bodies by a system of stresses in the dielectric separating them; as, however, at present we wish to compare Maxwell's theory with other theories which do not touch upon this point, we shall discuss this part of the theory separately later on and go on to discuss those points which are involved in all the theories.

The next great point in Maxwell's theory is the development of Faraday's remark that the electrotonic state may exist even in non-conductors, *i.e.*, that the dielectric surrounding a changing current is acted on by electromotive forces which polarise it. This statement is one as to whose truth nobody seems to entertain any doubt, whilst the statement that changes in the dielectric polarisation produce effects analogous to those produced by ordinary conduction currents is by no means so universally received; and yet the one seems the necessary consequence of the other.

(To be continued.)

THE CHANGES PRODUCED BY MAGNETISATION IN THE LENGTH OF IRON WIRES UNDER TENSION.*

In a paper communicated to the Royal Society about a year ago, the author discussed the results of certain experiments made by Joule in relation to the effects of magnetism upon the dimensions of iron and steel bars.

It is well known that the length of an iron rod is in general slightly increased by magnetisation. Joule enunciated the law that the elongation is proportional in a given bar to the square of the magnetic intensity, and that it ceases to increase after the iron is fully saturated. The author's experiments, made with a greater range of magnetising forces and with thinner rods than those used by Joule, showed that if the magnetising current were gradually increased after the so-called saturation point of the iron had been reached, the elongation, instead of remaining at a maximum, was diminished, until, when the current had attained a certain strength, the original length of the rod was unaltered, and if this strength were exceeded, actual *retraction* was produced.

Joule also found that when the experiment was performed upon an iron wire stretched by a weight, the magnetic extension was in all cases diminished, and if the weight were considerable, magnetisation caused retraction instead of elongation. From these facts he appears to have formed the conclusion that, under a certain critical tension (differing for different specimens of iron, but independent of the magnetising force), magnetisation would produce no effect whatever upon the dimensions of the wire. In one of his experiments a certain iron wire loaded with a weight of 408lbs. was found to be slightly elongated when magnetised; the weight was then increased to 740lbs., with the result that magnetisation was accompanied by a slight retraction. In both cases the magnetising currents varied over a considerable range, and the smaller ones were without any visible effect. Commenting upon these results, Joule conjectured that "with a tension of about 600lbs (which number is roughly the mean of 408 and 740) the effect on the dimensions of the wire would cease altogether in the limits of the electric currents employed in the above experiments."

In reference to this surmise the author in his paper of last year expressed his belief that, if Joule had actually made the experiment, he would have found that the length of the wire was increased by a weak current, that a current of medium strength would have had no effect whatever, and that one of his stronger currents would have caused the wire to retract. He had, in fact, reason to believe that the effect of tension was to diminish the "critical magnetising force" (which produces maximum elongation), so that the retraction which is found to occur in all iron rods when a sufficient magnetising force is employed, is observed with smaller magnetising currents when the rod is stretched than when it is free, but want of suitable apparatus prevented him from submitting this idea to the test of direct experiment.

He has lately modified the instrument, which was described in his former paper, in such a manner that it can be used for observing the effects of magnetisation upon rods and wires under traction, and the results of a series of experiments made with it are presented in a synoptical form in the subjoined table. Four specimens

* Abstract of Paper read before the Royal Society on March 25, by Shelford Bidwell, M.A., LL.B.

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	Commercial iron wire, diam. 1·2 mm.				Charcoal iron strip, section 3 mm.				Hard wire, diam. 2·6 mm.		Soft wire, diam. 3·25 mm.		
Stretching load	3 lbs.	7 lbs.	10 lbs.	14 lbs.	3 lbs.	7 lbs.	10 lbs	14 lbs.	3 lbs.	14 lbs.	3 lbs.	14 lbs.	
Smallest current producing sensible elongation	0·043	0·064	0·084	...	0·033	0·020	0·029	0·064	0·12	0·15	0·064	0·033	Amperes.
Current producing maximum elongation......	0·49	0·39	0·23	...	0·44	0·33	0·27	0·15	0·70	0·58	0·70	0·58	Amperes.
Current by which original length is unaffected	0·99	0·73	0·47	0·23	1·30	0·90	0·77	0·53	0·99	0·94	1·24	1·09	Amperes.
Maximum elongation in scale divisions	2	1·5	0·5	...	10	6	4	1	2·5	2·5	6·5	4·5	Scale divisions.
Retraction with current of 1·6 ampere.........	6	9·5	11	11	9	15	18	20	11	11	8	11	Scale divisions.

The magnetic field of the centre of the coil = current × 92. One scale division = one five millionth part of the length of the wire.

of iron were used. The first was a wire of commercial iron, 1·2 mm. in diameter, which had been softened by heating in a gas flame; the second was a strip of annealed charcoal iron, 5·5 mm. wide and 0·55 mm. thick, its sectional area being about 3 mm.; the third was a piece of hard unannealed wire, 2·6 mm. in diameter; and the last was a wire of very pure soft iron, 3·25 mm. in diameter, which had been carefully annealed. These were successively fixed in the apparatus, and loaded with weights varying from 3lb. to 14lb. While under the influence of each load four observations were made in the case of each wire:—(1) A determination was attempted of the smallest magnetising current which sensibly affected the length of the wire in the direction of elongation or retraction. (2) The current producing *maximum* elongation (if any) and the extent of such maximum elongation were found. (3) A determination was made of the critical current which was without effect upon the original length of the wire, *i.e.*, the current of such strength that a weaker one would cause elongation and a stronger one retraction. (4) The retraction produced by a fixed current of 1·6 ampere was measured.

The figures recorded in the table disclose the following facts:—

(1) The effects produced by magnetisation upon the length of an iron wire stretched by a weight are in general of the same character as those which have been shown in the former paper to occur in the case of a free iron rod. Under the influence of a gradually increasing magnetising force such a wire is at first elongated (unless the load be very great), then it returns to its original length, and finally it contracts.

(2) The maximum elongation diminishes as the load increases according to a law which seems to vary with different qualities of iron. If the ratio of the weight to the sectional area of the wire exceeds a certain limit, the maximum elongation (if any) is so small that the instrument fails to detect it.

(3) The retraction due to a given magnetising force is greater with heavy than with light loads.

(4) Both maximum elongation and neutrality (*i.e.* absence of both elongation and retraction) occur with smaller magnetising currents when the load is heavy than when it is light; retraction, therefore, begins at an earlier stage. Thus the anticipation expressed in the author's former paper is justified.

(5) The phenomena, both of elongation and of retraction, are, as might be expected, greater for thin than for thick wires, and for soft than for hard iron.

THE INDIAN TELEGRAPH DEPARTMENT.

The following letter appears in the *Homeward Mail*, over the signature of "600 Wallah":—

The staff sanctioned for the department in 1866 was 21; 1 director-general, Rs.2,500 to Rs.3,000; 1 deputy director-general, Rs.1,500 to Rs.1,800, by annual increment of Rs.50; 4 superintendents, 1st grade, Rs.1,050 to Rs.1,500, by annual increment of Rs.75; 8 superintendents, 2nd grade, Rs.800 to Rs.1,000, by annual increment of Rs.50; 7 superintendents, 3rd grade, Rs.600 to Rs.750, by annual increment of Rs.30; 88 assistant superintendents, Rs.200 to Rs.450, by annual increment of Rs.25. The changes made in and before 1880 were 44:—1 director-general, Rs.3,000; 1 deputy director-general, Rs.2,000; 2 directors, Rs.1,600 each; 4 superintendents, 1st grade, Rs.1,125 to Rs.1,500, by annual increment of Rs.75; 8 superintendents, 2nd grade, Rs.900 to Rs,1,050, by annual increment of Rs.30; 12 superintendents, 3rd grade, Rs.800; 16 superintendents, 4th grade, Rs.600; 50 assistant superintendents, Rs.250 to Rs.500, by annual increment of Rs.25. These changes may be summarised as follows:—Pay of the director-general increased by Rs.500; pay of the deputy director-general increased by Rs.500; two directors created on Rs,1,600 each. Pay of 1st grade superintendent raised by Rs.75; pay of 2nd grade superintendents raised by Rs.100; pay of 3rd grade superintendents, raised by Rs.200; 5 superintendents, 3rd grade, created on Rs.800; 16 superintendents, 4th grade, created on Rs.600. Pay of assistant superintendents raised by Rs.50. In other words, the direction and superintendence were increased by 23 officers, and the assistant superintendents reduced by 38 officers. The pay and service of the 21 senior officers on promotion are given below:—One 26 years, Rs.3,000; one 22 years, Rs.2,000; one 25 and one 22 years, Rs.1,600; direction, four. One 27, two 24, and one 21 years, Rs.1,125; superintendents, 1st grade, four. One 28, one 27, two 25, one 24, two 22, and two 19 years, Rs.900; superintendents, 2nd grade, nine. Two 22 years, Rs.800; superintendents, 3rd grade, two. One 25 and one 21 years, Rs.600; superintendents, 4th grade, two. The pay and service of the 23 remaining superintendents on promotion were:—One 18, one 17, two 15, four 14, and one 12 years, Rs.800; superintendents, 3rd grade, nine. One 18, one 16, four 15, three 13, three 12, and two 11 years, Rs.600; superintendents, 4th grade, fourteen. The distribution return of the department for 1885 gives the service of the 44 senior officers up to April 1, 1885, as follows:—

Service Years.	Direction.	Superintendents.				Total.	Grand Total.
		1st.	2nd.	3rd.	4th.		
30	—	—	—	—	1	1	1
29	—	—	1	—	—	1	2
28	2	1	—	—	—	3	5
27	1	1	5	3	—	10	15
26	—	1	—	—	—	1	16
24	1	—	—	—	—	1	17
22	—	1	—	—	—	1	18
21	—	—	—	—	1	1	19
20	—	—	2	—	2	4	23
19	—	—	—	2	1	3	26
18	—	—	—	2	2	4	30
17	—	—	—	5	3	8	38*
16	—	—	—	—	6	6	44*
Totals.....	4	4	8	12	16	44	

* Appointed since 1868.

There were besides 65 assistant superintendents, 15 in excess of the sanctioned number. Of the officers appointed since 1868 only 14 were in the grades of superintendents, and this has been accomplished by the supersession of senior officers. Since January 1, 1868, the pay of the 8 senior assistant superintendents in the fourth grade has been raised from Rs.600 to Rs.700. The remaining 8 form a new grade, called the fifth. The relief afforded is not calculated to satisfy the recipients or their less fortunate colleagues, when it is remembered that the pay of their predecessors rose from Rs.600 to Rs.850 by annual increments of Rs.30. It appears very hard that, while so many are deprived of promotion, those enjoying higher salaries—Rs.900 and Rs.1,125—should have their pay increased to Rs.1,050 and Rs.1,500 by annual increments of Rs.30 and Rs.75 respectively. To those who have been grievously disappointed it would be no more than just to give Rs.750 after seventeen years' service, and Rs.1,050 after twenty-three years' service, according to the scheme of 1866.

ELECTRICAL CONDITIONS OF THE HUMAN BODY.

LECTURE III.

Dr. Stone: Mr. Vice-President and Gentlemen, I hope I was able to showi n my second lecture the effects of the polarisation which occurs in all electrolytes and in the human body, to an extent not previously measured so far as I know. I also showed the important bearing of these physical effects on the physiological observation of electrotonus. But, before I proceed to the subject of to-day's lecture I have to acknowledge my faults—I have to confess my sins. In the first place, in the skeleton form of Mance's method a minus was omitted between the two terms of the numerator A - B. I will not say whether that was my fault or

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not, but it certainly led me to describe the formula as one of multiplication. The product divided by the sum is so familiar a formula to electrical workers that the mistake was natural. But the method really is the difference of two quantities—two compound quantities, both of them called A and B, divided by a third compound quantity called C. I understand from Dr. Ord that the mistake was, however, so very obvious that I need not occupy more time in explaining how it arose. Dr. Ord was kind enough to suggest to me that I did not make the demonstration of the two sounds in the induction discharge quite so clear by the telephone as I ought to have done, and, therefore, I propose to do it in another way to-day, and as it were to carry the practice of demonstration, so well known in this college, a step further. I have arranged a contact breaker, and I will ask you to take the telephones whilst I perform the experiment as I think more satisfactorily. I shall make and break so very slowly that what by habit has become easy to me will be easy to you. It was my fault entirely before, being myself so long accustomed to these observations, the tick, tick being a little too close together. [Experiment.] Now it is ticking doubly, but it is distinctly audible, like the tick of a lever watch. That has been made a great physiological point of, but it is reproduced here, without physiological apparatus, without the galvanoscopic frog, entirely by means of the telephone Here I will end my confessions, and I am now enabled to begin the subject of to-day. I have to speak this afternoon of induced currents, and the subject of induced current has been gone over and over again in every text book *ad nauseam*. I do not wish to repeat all that can be read therein. The current of induction is momentary: but it can also occur in the same wire, and when occurring in the same wire it is called the extra current. The current on making is weaker than that of breaking, because the extra current in the first wire antagonises the make and assists the break. A sort of momentum is produced, and an opposition action goes on. Now these induction currents came very early into physiological and therapeutical use. They succeeded, indeed, very soon upon the discovery of electricity, which dates from before the present century, and the reason, I believe, of this is, first, from their obvious effect on the sensory nerves; secondly, from their valuable action on muscles as stimulants; and, thirdly, from the remarkable work done by Duchenne some thirty years ago. Now, I recollect Duchenne well when I was in the hospitals of Paris about 1856, and there cannot be the least doubt that his was a very clumsy and primitive induction coil, with which he accomplished by patient labour a most marvellous work. He isolated several new nervous diseases. He tested the reaction of muscle to stimulants, and he made quite a new era in our knowledge of electrical stimulus. But the current used by him was not specially or specifically electrical. He had a good muscle stimulant. His coil was merely a convenient way of testing the susceptibility of muscle, and it had no great electrical value. This has done some damage to subsequent electrical work because it has been taken for granted that the convenient stimulus which he used in the induction coil had some bearing on electricity. In the higher branches I believe it has none. For testing the contractility of muscle it is still unequalled. It is also most valuable as a means of keeping up irritability of muscle which has damaged by metallic impregnation of lead, or from which by nerve injury all the motor nerve influence has been cut off. But we must recollect that this machine of Duchenne is a muscle stimulant; it is not a nervous stimulant. It is not necessarily an electrical phenomenon at all. No doubt it might be used also, though with more caution, to test sensation. But here individual differences of temperament step in, and the tolerance to induced currents is extremely various in different persons. This has been discounted by the class of people who attend fairs and exhibitions, and who have an enormous machine with a vast amount of bright apparatus on which they ask you, for the remuneration of one penny, to test your strength. All you test in a case like this is your susceptibility to a certain amount of induced current, and this no doubt varies very much. If the points were taken up scientifically, something might be made out of it; but even this is not really an electrical phenomenon. No doubt induced current may go a stage further, and do good service in stimulating even so deep seated a muscle as the diaphragm in asphyxia or in suspended animation. In cases of opium poisoning I believe the induction current should be used, one pole to be over the nape of the neck and the other pole moving about in front of the abdomen, because it will set up respiration when it seems to have been lost. Besides this it is of great value in the lecture room. It is a convenient and effective means of physiological demonstration. But there its use ought to end. Even in physiological research it is unsafe, and I very much regret that some recent and valuable researches as to the localisation of brain functions have been founded on the use of induction currents. And, firstly, for this reason, that there is not only no proof that the current passes through the region included between the poles, but there is very conclusive evidence, I believe, that it diffuses itself widely and irregularly in all directions with enormous differences, according to small differences of conductivity. But, secondly, I may even say it is very doubtful if a current passes through a moist substance like the brain tissue at all. I have to show you that it is possible and probable—I believe that it is true—that it only starts a series of laminated polarities in a bad conductor, which resembles very much the laminated condition of a condenser. For this reason I spoke of the condenser in my syllabus, and although I had withdrawn the term, I think there is something like a condenser action in this laminated, this polarised state, which the opposite currents from an induction coil may produce in a feeble conductor. However, when I speak of induced currents of that kind I mean the currents obtained from an induction coil. You can make induction currents by a totally different method from this, and if they are to be used with any certainty they should be used after another fashion —I mean alternating currents obtained by commutating battery currents. Here you are able to measure the electromotive force of the battery. Now, I had intended to speak of these alternating currents as produced by a tuning fork, but I have found this would pass beyond my limits of time; besides, in the next place, I shall show you presently that it is not necessary further to investigate it, because, as a matter of measurement, it must be thrown aside. But the measure of induction currents is a question of some importance, and of the more importance because, in reading a medical periodical a few months ago, I saw a review which commenced by the general statement that it is impossible to measure induction currents. Now this, strictly speaking, is not true, and I shall proceed next to show you three methods by which induction currents can be be measured—first of all by Hartmann's dynamometer. But it is too delicate to be shown in a lecture room. It is very good indeed in the silence and quiet of the laboratory. It may be briefly described as a galvanometer in which the moving needle has been replaced by a moving coil. The instrument is in very great use in electrical investigations, but it is hopeless to produce any demonstration with it in a lecture like this. I therefore prefer to take the two simpler and rougher modifications, which answer medical purposes better than that—to be used at a distance with the reflected telescopic image of the scale. But I have two here which will answer our purpose, and which are not so difficult to demonstrate. Here is, first, my old dynamometer, which went across the Atlantic with me to the British Association meeting at Montreal, and here is another one, but which, I believe, has not been employed before in this particular way, and in which the whole trouble of having a current through a coil is removed by using a sheet of soft iron. The first I will describe as a coil made of light aluminium wire. Without diminishing the electrical contact the aluminium is a substance which for a given bulk is the largest conductor of electricity. By making an aluminium coil you get a light and moving coil, which will act under our small currents. But even that I have since found can be dispensed with. I do not claim to be the discoverer of it; it was discovered in Italy; but I have made with my own hands an instrument, using a coil from another galvanometer, which will demonstrate this very well. If instead of an aluminium coil through which the current is passing, you take two sheets of ordinary or soft iron, they so rapidly change their polarity that they are equivalent to a coil in which a magnetic force is developed. Two soft iron sheets are mounted here between two coils, and I shall not waste very much time on this experiment, and I will only just turn the handle of the exploder, which produces a moderate induction current in alternating directions—quite tolerable by the human being—so that this is within the range of what we can stand and use. [Experiment.] Now, there I have induced magnetism in these two plates of iron, and I think that will be the dynamometer of the future for medical purposes. It avoids so many complications and difficulties. I will do it once more. [Experiment.] But a far better and more accurate determination can be obtained by that most beautiful instrument, the quadrant electrometer. Now, the quadrant electrometer, like the dynamometer, is far too delicate to attempt to demonstrate with it in a lecture room, but I have made determinations with it, in which I had the valuable assistance of the professors of Cooper's Hill College, and it is the united work of myself, Mr. Gregory, and Prof. Stocker that I shall reproduce here. I have given two formulæ there by which the determination on the electrometer can be made. I do not intend to lay much stress upon it now, but the general principle of it is this—that if the currents are alternating the needle of the Thomson electrometer must be put in communication with one of the quadrants, preferably with one of the quadrants and then the other. The upper diagram is that given by Prof. Adams in his Cantor lectures, and in the other diagram [indicating it] there is the mode of measurement given me by Prof. Hopkinson. Time will not allow me to dwell upon them; but I will give you a *résumé* of certain determinations made in that way with a fine quadrant electrometer at Cooper's Hill. The process we adopted was to compare the deflection obtained on the electrometer, that is the difference of potential with an alternating current with that of a battery of which we knew the force and which we could measure. "In these measures," says Mr. Gregory, writing to me, "the negative pole of the battery was to earth, the positive pole being connected at will to either pair of quadrants, and the needle also at will to either pair, giving four readings for each observation. I give only the means which agree very well." The determinations are ·149, ·151, and ·146 each, which gives a mean ·1486. Using the mean value we worked out that the electromotive would give a deflection of 107, which we got. It came out 38. Then we took the same determination with the same electrometer, with the same constant and batteries, and it came out 107·25. This agrees very well, says Mr. Gregory (I wish they would all agree so well), so that it will be very easy to value the electromotive force corresponding to any deflection by the formula which is made here. We then tried the making and breaking of contacts about ten times a second. The deflection was obviously somewhat low, so that possibly the effect of rapid alternations is to lessen the deflection for the same electromotive force. But observations seem to point to this, that the mean electromotive force developed by the induction coil (and the induction coil we used I shall show you presently) is certainly less than 50 volts, and probably nearer 40. I think we may take it at 40. Of course, this is not the maximum electromotive force. Even the electrometer integrates to a certain extent. But still, this measurement, which I think has not been made before, may be taken as sufficient for all our purposes. I do not think I will occupy more time on this subject. We have made a measurement—and a successful measurement—of the force of an induction coil of the ordinary form, and this, instead of being eight or ten volts, is at least 40, and may go quite up to 50. Now, I want to show you a curious result that comes from using this induced current of from 40 to 50 volts passing in an alternating current through the human body; and here again I shall have recourse to my telephones, for I have discarded the galvan-

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ometer for the more sensitive and delicate telephone. I shall introduce the human body into the circuit, and I shall use for this purpose Kohlrausch's combined induction coil and meter bridge with the telephones. Now, here the electromotive force which is working it is only four volts—two bichromate batteries—and I will ask you to put a telephone to your ears. I have a quarter of a metre here of platinum silver wire, and a number of fixed resistances, so I will employ a hundred resistances, and then I will employ a thousand, but I am afraid my human patient will not stand it, and when I get balanced you will find that the telephone will cease to speak. [Experiment.] I get 600 ohms against 1,100 given by the constant current. Now, this is very important. The same man whom we tested at the first lecture only shows 600 ohms resistance, whereas to the constant current he shows 1,100, and this is invariably the case, and I believe the observation is absolutely new. Of course, however, the first result of it is that it is clear that this induction current cannot be used for the measurement of human resistance. We lose something there. But, on the other hand, we get physiological facts of very considerable importance, and the explanation of this difference is what I will next proceed to consider. It is susceptible of several explanations. In the first place, the human body, like all imperfect conductors, in all probability is more permeable to high tension than to low tension currents. This occurs in all feeble conductors. I think the effects of these experiments alone fairly prove this, and there are many that you come across in telegraphic work which prove it. Indeed, the diagram we had last time, when we used an E.M.F. of two volts, four volts, six volts, and eight volts, showed a distinct falling of resistance as the E.M.F. was increased. But there is a great deal more than this. It is probable, as I said before, with the rapid intermission, the current does not pass at all, or not fully, until it is met and annulled by the next current in the opposite direction. Thus the body would be like the leaves of a book in a stratified or laminated condition, or more closely like an elastic body transmitting the waves of sound with alternate plates of condensation and rarefaction represented in this case by positive and negative polarities. Now, curiously enough, this comes out from Du Moncel's early and successful experiments. He found that there was inside the charged body something like the leaves of a book. There was the new polarised current obtained at the extremities, and at first giving an opposition current, which soon yielded to the old current which had been established internally. This seems to me to be a proof that the body can take up a series of laminated polarities, and does not transmit these induced currents. There was a long controversy on this subject (which I have not time to go into) in *The Electrician*, in which some good letters were written. I was the starter of the subject, advocating these views, and I was induced by Sprague and Blakesley, who have contributed very valuable illustrations in induced and other currents, to modify my opinions. But there is a third reason which, I think, ought to be considered, and that is, as Dr. Oliver Lodge has suggested to me, that an alternating current ought to show too low a resistance because of the electro-chemical capacity of the body which the current would treat as conductivity—the reciprocal of resistance. If we were to measure the resistance of a perfect condenser with alternating currents it would not come out infinite even if the insulation were as perfect as it could be made. Here, again, was the reason for my putting into the syllabus that there was something like a condenser action in the human body. Lastly comes the fourth point, and, as I believe, there is considerable self-induction. Now, self-induction is a word which involves a great deal of difficulty. It is to be avoided in all induction coils, and in all resistance coils. The possibility of its playing a considerable part in the actions now before us was brought strongly before me only two months ago by a highly suggestive paper by Prof. Hughes read before the Society of Telegraph-Engineers on January 23th of the present year. He gives a very good account, and a very perfect account of what is known of self-induction. Induced or secondary currents in a double circuit were discovered by Faraday in 1831. The phenomenon of self-induction, or an electric current on its own wire, was observed by Henry in 1832, and enlarged upon by Faraday in 1834. He proved that by sending a current through a wire a momentarily induced current in the opposite direction is evoked in its own wire, and also on the cessation of the primary current excitement is induced on the secondary. I will not go further into that now. What I have to note here is that Prof. Hughes makes two different periods—the stable period and the variable period. The ordinary current from the battery is not in itself used—is not tested—until it has got to the stable period, but the induction current is in the variable period. There is some controversy as to the mathematical interpretation of these facts; but my own belief is that in the main they point to a new direction of research which may be utilised by physiologists. He divides the current into stable and variable periods. The continuous current is stable, and the interrupted variable, so that it is in the latter that induction takes place. Prof. Hughes has brought his improved method of investigation forward in place of the time-honoured Neef's hammer, as in Du Reymond's coil. He uses his own invention, the microphone, or, still better, a small contact-breaking clock. This enables the ordinary meter bridge to be used for measuring resistance, and if time allowed me I should show how it works. But you may combine this mode of measurement with Prof. Hughes's sonometer. I have here a simple form of the sonometer, in which the induced coil slides along a bar. As I slide this along the bar I think you will be able to detect the effects of induction. [Experiment.] Now, I am very glad to have been able to show what I believe is a perfectly new experiment, and I will admit that it is somewhat difficult to show. If these coils be set up at measured distances, and an interrupted current passed through the primary coil, the patient, and a known resistance in the secondary circuit on either side of the telephone, good measurements can be obtained. There is a still further modification of the instrument that I do not propose to go into to-day. This is Prof. Hughes's last discovery. He blends together a Wheatstone bridge and a sonometer, by which I hope we shall be able to balance, if it will act, not only resistance but self-induction. I have not been able to make any definite measurements yet. The instrument has only been before the public since January, and this particular instrument, which takes some time to make, has been in my hands only for a fortnight or three weeks, but I think if I cannot give exactly the measurements I can give demonstrations which will enable you to see what it means. But whilst this is being put up I will occupy your time by a few general considerations. I think I have been able to show you that here is a great field for future research — that the whole basis of physiological electricity requires strengthening and re-examining. It is a stately building built by Du Bois-Reymond and many others, of which the foundations are unsafe. Until these are made firm the whole superstructure is in danger. But if, on the other hand, we set to work and strengthen the foundation we shall in the course of the necessary explorations come on many precious discoveries. Already the analogies between the nerve force and this great physical force—electricity—are becoming very strong, and one such, on inhibition, was published in *Nature* by Dr. Lander Brunton. He took up the theory (I hope it may be true) that different lengths of nerve conductors might transmit wave influences at a period such that there should be interference, and so inhibition might occur; and I ventured at the end of my syllabus to place another such attempt to go out into the infinite unknown, by saying that there are many analogies between the condition of the human body and a duplexed Atlantic submarine cable. The curious thing about the submarine cable is that its results are produced at the far end, and that nothing is shown at the near end. How like this are many nervous actions of the human body! When you see these strong analogies you cannot resist the impression that nature must have worked upon one plan, and although we have not found it there must be some link between the two. I do not wish to lay any stress on the duplexed cable other than that it produces on my mind, and it may on yours, a strong feeling that the analogy is too great not to be in a certain sense real, although not yet discovered. And we are coming upon this every day. It is a most desirable thing that we should come upon this, because every connection that can be found between physical facts and that unknown vital region which we have been accustomed to investigate is one step further on the road to truth, one of the mysteries taken out of the unknown and added to the known. I shall conclude by offering a few observations as to what are the hopeful directions of electrical work. I see the therapeutical use of electricity looming before us in the direction of muscular enfeeblement, palsy, and what has been called reflex action. I am not quite certain of its value on the sensory nerves in cases of neuralgia. I mentioned and gave you the details of a case of sciatica, which I have no hesitation in saying was instantly and momentarily cured by a continuous current. I believe it is of great value in neurotic cases, such as locomotor ataxy. It has the power of loosening chemical compounds in the body. Therefore, it follows that it should be an eliminative, and that I am absolutely sure it is, because I have extracted from a fellow creature by electrical action 3 milligrammes of copper. The same thing has been done often and often with mercury. I think that concludes what I have to say on the subject of electricity. But beyond that I have something to say. I have to thank you all. I have had the intelligent support of my colleagues. I have been honoured by the presence of my brother censors, and I have received the greatest kindness from all connected with the college. I have had the patronage besides of men not belonging to the medical profession, like Sir Henry Mance—an honour which I cannot too highly appreciate—and I have enjoyed the careful attention of many of my students. I thank you all sincerely, and I will finish by a well-known formula, thus reviving a time honoured practice of this learned body:—

Dixi quod felix faustumque sit hinc collegio.
Vos omnes Volete et plaudite.

COMPANIES' MEETINGS.

Reuter's Telegram Company (Limited).

The twenty-second ordinary general meeting of the shareholders in this Company was held on the 22nd inst. at the offices, 24, Old Jewry, Colonel James Holland presiding.

The SECRETARY (Mr. Griffiths) read the notice convening the meeting, and the report of the Directors was taken as read.

The CHAIRMAN: It is quite unnecessary for me to say that it is matter of very great regret to us, as, no doubt, it is to you, that we have to produce to you a report and balance-sheet without any dividend—for the first time, I may say, in the records and annals of the Company; but those gentlemen who may chance to recollect some of the few remarks I made at the last meeting will probably not be surprised at the fact. I should like just to quote a small portion of my speech this time last year, which to a great extent prefigured what has happened. I stated then:—"If you will turn to the balance-sheet you will find that the receipts have been £3,700 more than last year, which shows that, though the business has not fallen off, on the other hand, the cost of procuring that intelligence has increased by £6,000. It will be, therefore, a serious and anxious duty for us as the engagements now standing with the Press fall in to endeavour to make such fresh agreements as shall satisfy the shareholders that the moderate interest which we look for upon our capital shall be made good in future. It is evident that with war constantly on the horizon the expenses must increase." Well, it was not in

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our power until a very late period to moderate in any way the agreements with the Press, because those agreements were made for certain fixed definite periods. When that period elapsed we had sundry communications with the various leading newspapers, and the result has been, I am happy to say, that they, seeing the justice and the necessity of the case, have agreed, in future cases of wars or great disturbances, such as to necessitate a very considerable addition to our expenditure, that they will on their part increase the amount of remuneration for our services to an extent which will practically prevent any recurrence of the present rather unhappy experience—that is to say, of no dividend. That is the bright lining—or a portion of the bright lining—to the cloud which is just now hanging over us. When I last year made the remarks which I have just quoted, we had a hope that war-like operations had ceased, or were about to cease, and that, therefore, notwithstanding the heavy expenditure we had incurred without return, we might have a moderate profit at the end of the year; but since then from Khartoum to Burmah has been one unceasing round of war of one kind and another. The Rangoon affair, although a satisfactory matter as respects the interests of the country, has been, as all wars are, a very unsatisfactory one for us, as we had to incur considerable expense in order to be first in the field—as it is our duty to be—our duty to you as well as to the public. We have also had to suffer—as mercantile men generally and the public have had to suffer—from the depreciation in silver. Exchanges have been very unfavourable to us, and our remittances from India have been very considerably "watered." There has also been very considerable mercantile depression, extending for a very considerable period, and we know no more than you when that is likely to end. All we can do is to hope that it may end, and that we may have no more wars—for some months to come, at any rate. Turning to the balance-sheet, there is nothing of any special consequence to note in it. The various items under the heads of "sundry creditors" and "sundry debtors" have all run off. The current expenditure has been a trifle less than that of the preceding year, but the telegrams and agencies—the great item of cost—have been £1,500 more than the very heavy expenditure on the same account in the preceding year. All this is simply to account for the unhappy fact of no dividend; but I am glad to say that it is by no means a hopeless affair. First of all, as I have told you, the Press have come forward very handsomely to meet us in the matter of cost in case of future wars or disturbances, and I am very glad to be able not only to give you this general assurance of brightening prospects, but something beyond. Although we have not yet got our figures as to the receipts for the first quarter of the year, we know that the expenditure on the telegrams for that portion is upwards of £2,000 less than it was in the corresponding period of last year. That is a solid fact, and therefore gives us very justifiable grounds for hoping for much better things. I may further add—which is also *pro tanto* satisfactory—that we have no bad debts. That is all I have got to say with regard to our balance-sheet and report. There are two other matters I wish to allude to. One is the absence of our esteemed colleague Baron de Reuter, who would have been present at this meeting, but unfortunately his ill-health has compelled him to reside for a time abroad. I may say, however, that we are in frequent communication with him, and I am authorised to state that he fully shares in the views which I have set forth, and on the line we have taken. I have also got to remark on an unhappy loss at our Board. Since I met you last year our esteemed and much-respected colleague, Mr. Stopford, has died, and I am sure you will regret his loss very much. Mr. Stopford was one of the original directors along with Sir John Hay and myself—one of the first Directors of the Company, and you cannot be connected for over twenty years with a man without knowing something of his character. We had all learnt to like and esteem Mr. Stopford as a man of business and worth, and an excellent man. I have no further remark to make, and I will now put the motion, which is, "That the report and balance-sheet now presented be received, adopted, and entered on the minutes."

Admiral the Right Hon. Sir J. C. D. HAY, Bart., K.C.B., seconded the motion.

The CHAIRMAN invited discussion, offering to answer any question which might be asked of him; but no one rising to address the meeting, he put the resolution, and it was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. HERBERT DE REUTER (the Managing Director), Admiral Sir John Hay was re-elected to his seat at the Board.

The auditors (Messrs. Quilter, Ball, and Co.) having been re elected, on the motion of Mr. BRADSHAW,

Mr. LOVEDAY proposed a vote of thanks to the Chairman, Directors, and secretary, observing that they had to thank the Board for keeping nothing from them. If the shareholders got no dividend, they got the truth, and he thought when the Chairman had given them a reasonable promise of dividend for the future, they might take that as an earnest of what was to come.

Mr. WOLFF seconded the motion, which was carried unanimously.

The CHAIRMAN: On behalf of my colleagues and myself I have to thank you very much for your kind vote. It is particularly gratifying to us, because we all know, from our own experience and our own feelings, that a meeting where no dividend can be recommended is one that generally rather exasperates the feelings of shareholders, and a kind vote to the Directors is very seldom the result. I repeat my hope and belief that we shall have a better meeting this time next year.

The proceedings then terminated.

TO ELECTRICAL APPARATUS MANUFACTURERS.—EMPLOYMENT WANTED at the above by a Watchmaker. Well acquainted with all kinds of Fine Turning, lathe and hand.—Address, WATCHMAKER, *Electrician* Office.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. APRIL 23.		BUSINESS DONE WEEK ENDING APRIL 23. Highest.	Lowest.
Anglo-American	30½,	31½	33	30⅞xd
Do. Preferred	52½,	53½	55½	51½xd
Do. Deferred	9¾,	10¼	10¾	9⅞
Brazilian Submarine	10⅞,	11⅛	11⅛	10 15-16
Cuba	10¼,	10¾	10¾	10⅝
Do. Preference	18,	19	18½	18½
Direct Spanish	1½,	2	—	—
Do. Preference	9½	10½	—	—
Direct United States Cable	9¼,	9½	9 9-16	9¼xd
Eastern Telegraph	11⅛,	11⅜	11 9-16	11xd
Do. 6 per Cent. Preference	14⅛,	14⅝	14¼	14 1-16xd
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	12⅛,	12⅜	12⅛	12⅛xd & [bonus
German Union	9¼,	9¾	9½	—
Globe Telegraph and Trust	6½,	6¾	6¾	6 9-16xd
Do. Preference	13½,	13½	13¾	13½xd
Great Northern	13¾,	14¼	14¼	13⅞
Indo-European	87½,	88½	—	—
Reuter's	6,	6½	6¼	—
Submarine	200,	210	207½	—
West India and Panama	¾,	1	—	—
Do. 1st Preference	9¼,	9¾	9⅜	—
Western Brazilian	7⅛,	7⅜	7½	7 3-16
Western Union 7 per Cent. 1st Mortgage	121,	125	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	103½	—

TELEPHONES.

Consolid. Telephone and Maintenance	15-16,	1 1-16	—	—
Oriental	3-16,	5 16	—	—
United Telephone	12⅞,	13⅛	13⅛	12⅞

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2¾,	3¼	—	—
Do. (fully paid)	4¾,	5¼	—	—
Hammond Light (£3 15s. paid)	1-16,	3-16	—	—
Swan	⅞,	1⅛	—	—
Maxim-Weston	¼,	⅜	—	—

MISCELLANEOUS.

Telegraph Construction	36½	37½	37½	36⅞
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23¾	23

THE DIRECT UNITED STATES CABLE COMPANY (LIMITED).

NOTICE.—REDUCTION OF TARIFF.

On and after 5th MAY, 1886, the TARIFF between the United Kingdom and all the principal Telegraph Stations in the United States of America and Canada viâ DIRECT CABLE will be SIXPENCE per WORD.

Special arrangements can be made at the General Offices of the Company for the transmission of PRESS MESSAGES at THREEPENCE per WORD.

Complete Tariff will be issued shortly.

J. W. FULLER, Secretary and Traffic Manager.

General Offices, 50, Old Broad-street, London, E.C.

J. H. GREENHILL,

(NEW) KING ST., BELFAST, IRELAND.

ELECTRIC LIGHT ENGINEER.

Manufacturer of Dynamo Machines with Wrought or Cast Iron Magnets for Arc or Incandescent Lighting, and of a capacity from 5 to 500 lamps of 20 candle power, nominal.

Complete Installations contracted for on Moderate Terms.

Reference can be given to firms who have had permanent Installations erected and constantly at work for the last four years.

THE MACHINES ARE OF VERY HIGH EFFICIENCY.

NALDER BROS.,

Instrument Makers, Electricians, and General Electrical and Mechanical Engineers,

Office: 8, Victoria Chambers, WESTMINSTER, S.W.

Steam Factory, Brent Electric Works, The Ham, Brentford. Laboratory, The Butts, Brentford.

Manufacturers of Resistance Boxes, Wheatstone Bridges, Thomson and other Galvanometers, Lampstands and Scales, Electrometers, Condensers, Keys, and Electrical Standards of every description.

VOLTMETERS and CURRENT INDICATORS.

Cathetometers, Micrometers, Bar Callipers, and all descriptions of Electrical, Physical, and Mathematical Instruments. Experimental work undertaken. Chloride of Silver and other Batteries. Switch Boards, Switches, and Electric Light Fittings.

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Complete Installations of Electric Light undertaken. Engines, Dynamos, Motors and Lamps supplied.

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NOTES.

British Guiana. — The cable between Trinidad and Demerara, which was interrupted in March last, is now restored.

The West Coast of America Telegraph Company.—The gross earnings of this company for the month ending April 30th were £3,225.

The Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 30th ult. amounted to £3,055.

Eastern Telegraph Company.—The traffic receipts of this company for April amounted to £47,611, against £63,085 in the corresponding period of 1885.

Direct Spanish Telegraph Company.—The estimated traffic receipts of this company for the month of April are £1,597, against £1,510 in the corresponding period of last year.

Another Telephone Discoverer.—Dr. Cushman claims that he discovered the telephone in 1851 whilst experimenting with lightning arrestors upon a line he was engaged in building from Racine to Beloit.

Great Northern Telegraph Company.—The receipts in April were £19,800, and the receipts for the period of January to the 30th April, £78,480; for the corresponding months in 1885 £89,200, and 1884 £81,640.

The Eastern Extension, Australasia, and China Telegraph Company.—The traffic receipts of this company for the month of April amounted to £34,292, and to £41,233 in the corresponding period of 1885.

Reduction of Rates.—The Eastern Telegraph Company notifies that, by arrangement with the Brazilian Submarine Telegraph Company, the rates to South America are now materially reduced. Particulars of the reductions, which vary from 2s. to 3s. per word, are given in our advertisement columns.

Lighting Canals by Electricity.—The Canadian Government has decided to illuminate the Lachline Canal by means of Edison's incandescent light. It is expected that if this proves a success the Welland and other canals will be lighted on the same principle.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ended 30th ult. were £2,551, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

The Society of Telegraph-Engineers.—The next meeting will be held at the Institution of Civil Engineers, 25, Great George-street, S.W., on Thursday, 13th inst., when a paper "On Long Distance Telephony," will be read by Mr. W. H. Preece, F.R.S., past president.

The West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half month ended 30th ult. are £2,435, as compared with £3,857 in the corresponding period of 1885. The January receipts, estimated at £5,484, realised £5,477.

Electric Light in Palermo.—The *Economista d'Italia* of the 1st inst. announces the formation of an electric light company ("Societá Thomson Houston") in Palermo, with a capital of 500,000 lire, say £20,000. Subscriptions were invited between the 3rd and 5th inst. for an issue of 500 shares of 250 lire, say £5,000.

Liverpool Exhibition.—One of the courts in this exhibition, which is to be opened by Her Majesty on Tuesday next, is set apart exclusively for a display of various electrical apparatus. From the lantern at the top of the model of the Eddystone lighthouse an electric light of great power will be visible for miles around.

The Newry and Dessbrook Electric Tramway.—The new line of electric tramway, three miles long, between Newry and Dessbrook, has just been taken over from the contractor by the company. During the six months it has been working, 10,000 miles have been run, and 43,000 passengers and 8,000 tons of goods have been carried.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of this company during the month of April was 3,961, estimated to produce £3,300, against 4,319 messages, producing £3,886, in the corresponding month of last year. The traffic receipts for the month of January, estimated at £2,850, realised £2,891.

Photography by Electricity.—It is the opinion of M. Ottomar Volkmer, who has recently been writing on the subject in *Electricité*, that as soon as electricians can supply the electric light at anything like a reasonable price, it will be largely used in photographic studios in preference to daylight. We may supplement this by saying that in England it is being largely used by photographers.

Domestic Electric Lighting.—Recently the chairman of the Maxim-Weston Electric Light Company (Mr. Hugh Watt, M.P.) gave a reception at his private residence in the St. George's-road, S.W. A select company of scientific men were present, who, it said, expressed themselves greatly pleased at the success of the installation. A Weston dynamo was used, power being supplied by an Otto gas engine, both of which were placed in a wooden shed at the back of the house.

The Electric Light in Holland.—At Kinderdyk, near Rotterdam, the electric light has been introduced. Fourteen lamps have been placed in the principal street, and a few shopkeepers have adopted the system. The light is kept up from sunset till midnight, the dynamos being worked by two steam engines. The price charged per year per lamp of 16 candles is £1. 1s. 5d. where only one is used; for two, £1. 0s. 2d.; for five, 19s.; for ten, 18s. 4d.; and for twenty, 17s. 8d. each. The life of a lamp is estimated at 1,000 hours, and when it is exhausted it may be replaced for 3s. 9d.

Electric Music.—M. Semmola, says the *Electrical World*, a German investigator, one of the many who have experimented in this direction, has succeeded in producing musical tones from a metal plate by electrifying it intermittently from an induction machine. The plate is supported on an ebonite funnel and is a millimetre in thickness. The terminals of the induction machine are connected to opposite sides of the plates by wires, and the path of the current is interrupted so that sparks strike across. The plate then begins to sound, and it continues to sound even if a Geissler tube or a lead wire is interposed in the break.

Large Dynamo.—The Brush Electric Company, of Cleveland, it is said, are building the largest dynamo in the world. It will be 12 or 13ft. long, 5½ft. wide, and weigh ten tons. It will give a current of 122,500 amperes; number of watts, 245,000. In other words, it will be four times the size and capacity of the "Jumbo" machine exhibited by Edison at the Electrical Exposition at Philadelphia. The latter was adequate to the task of running 5,000 sixteen candle-power incandescent lights. This monster machine of the Brush Company will be

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shipped to Lockport, N.Y., and be used for the smelting of "aluminium." Five hundred horse-power will be required to drive it, which will be furnished by water, with the aid of turbine wheels.

AN ELECTRIC LAUNCH.—On Saturday last people passing between Charing Cross and Westminster Piers might have witnessed if not a novel at least an interesting experiment on the river with a small electric launch built by Messrs. Yarrow, and fitted with motors supplied by Mr. A. Reckenzaun. The little vessel, which carried its full complement of passengers, sped through the water with amazing rapidity, and caused no little surprise to travellers on the passing steamboats, who, of course, could see no visible means by which the launch was propelled. The speed attained was between nine and ten miles an hour with, and a little over seven against, the tide. We understand that Mr. Reckenzaun meditates a trip across the Channel at an early date.

ELECTRIC LIGHTING.—We are glad to hear that Messrs. B. Verity and Sons have obtained the contract for lighting the new Holloway College at Egham. Most of our readers know that the late Mr. Holloway built and endowed this college, and that it is one of the most ornate structures in the land, and, if anywhere, the electric light should here show to the greatest advantage. We have no doubt that the experience which Messrs. Verity and Sons have gained in designing the fittings at such places as the Holborn Restaurant will enable them to design most appropriate fittings for the new college. The installation will consist of some 500 16 candle-power incandescent lamps, and the current will be supplied by two Edison dynamos of the new form, either of which will be, if required, capable of supplying the whole of these lamps.

A LONG DISTANCE TELEPHONE.—Interesting experiments are still being made with the object of ascertaining whether persons provided with the telephone in Paris can correspond directly with telephone holders at Rheims. The distance separating Paris from Rheims is 172 kilometres, but, including the length of the subterranean telephonic wires, the distance is 220 kilometres. The lines serving for these experiments were two ordinary telegraph wires, one of which was the Rheims wire, and the other the Berlin wire, which had been adapted to the public telephonic service organised between Paris and Rheims by means of M. Van Rysselberghe's anti-inductive system. This system permits of telegraphic and telephonic despatches being simultaneously transmitted by the same wires without the slightest confusion, so that while telephoning was going on between Paris and Rheims the same wires were traversed by telegraphic despatches exchanged between Paris, Rheims, and Berlin. So far the experiments have proved very successful.

ANOTHER FRENCH ATLANTIC CABLE. — The Paris correspondent of the *Daily News*, telegraphing on Wednesday, says: M. Granet, the Minister of Posts and Telegraphs, has granted a charter to a French company for laying a cable between Brest and New York, *viâ* Guadeloupe. The authorisation, to become final, must, however, be submitted for approval to the Chambers as soon as they meet. All the directors are French, and it has been stipulated that the cable is to be manufactured in France and laid by French vessels. An important clause in the contract is that the State will guarantee a certain interest on the capital. It is apparent from the above that powerful influences have been at work to obtain this agreement. Cable industry cannot be well acclimatised in France, even with the tenderest nursing. The Government was obliged to order the new Senegal and Tonquin cables in England. M. Menier is the largest French cable manufacturer, but his business is relatively small. Is is not said what line the company would take with regard to eventual "pooling" arrangements of the other companies.

ELECTRIC LIGHTING.—The electric lighting at the Duke of Newcastle's estate at Clumber, referred to in our Notes of last week, has been carried out by Messrs. Blakey, Emmott, and Co., of Halifax. The large ball room which accommodates six hundred guests has been lit by the incandescent light, distributed over some fourteen fine chandeliers and a number of side brackets, the drawing room, card rooms, &c., being also similarly illuminated. The machines for generating electricity for these lights consist of three Blakey-Emmott dynamos, driven by one of Marshall's engines. Around the mansion and at the temporary stables (which afford accommodation for three hundred horses) the arc light is employed, Pilsen lamps of 2,000 candle-power being worked by dynamos made by the firm named. On the top of the mansion a powerful search light, capable of being directed to any part of the very extensive estate, is provided.—The *Sheffield Telegraph* has an amusing note upon what it terms a narrow escape from a great calamity. We are told that a "crystal bracket, which held an incandescent lamp, had broken, and the liberated flame, in swiftly lengthening tongues of fire, was licking the loop of lace around the mirror." At any rate Clumber was saved by two gentlemen with cool heads. What have Messrs. Blakey, Emmott and Co., to say to this?

CITY GUILDS.—We understand that Prof. Ayrton will, during May, continue his course of lectures on "Some of the Industrial Applications of Electricity." The first two lectures, on May 14th and 21st, will be on the "Electric Transmission of Power," and the following is an abstract of the proposed scheme of treatment:—"Waste of power in the conductors. Advantages and disadvantages of the parallel system of supplying electric power. Economy effected by the use of the series, or the parallel-series system. Most economical size of conductors. Heating of conductors. Uniform potential difference, or uniform current, along the mains. Use of accumulators, secondary generators, and motor dynamos in electric transmission of power. Practical results already obtained with electric transmission. Comparison of electric with hydraulic and wire rope transmission of power." On May 28th the lecture will be on "Electric Locomotion," according to the following scheme: "Tramcars carrying a store of electric energy. Electric launches. Methods of conveying electric power to moving vehicles. Electric, steam, horse, and wire-rope traction. Absolute blocking with electric railways. Telpherage. Probable future developments in the applications of electricity." These will be followed by other lectures on the probable future developments in the application of electricity.

THE MEXICAN TELEGRAPH SERVICE.—In his Presidential Address to the Mexican Congress Señor Diaz referred to important changes in the organisation of the telegraph service, which, he said, had been carried out with considerable economy to the State, and without any detriment to the service. Enumerating briefly the nature of the reforms, he stated that of a total length of 21,000 kilometres of lines only a portion of them were of general utility. As a large part was of local interest the working of such lines has been ceded to the various States for a limited time and on favourable contracts, a moderate amount being allowed them for expenses of conservation. Twenty such contracts for the cession of such lines have so far been concluded, the expenses of maintaining 5,000 kilometres of wires and the service of ninety-three offices having thereby been saved. Fifteen other offices which were not necessary have, he said, also been closed, besides other

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economies. Instead of crippling the telegraph service, he stated that the new reforms had resulted in a notable improvement in the facilities of communication between the capital and the provincial towns, the ports, and the important stations on the frontier. He stated, however, that the new changes had necessitated the immediate repair of most of the lines which were in a bad condition, and this had occasioned an outlay which had been reduced to the smallest dimensions compatible with efficiency.

Electric Light for Madrid.—We referred a week or two ago to a contention between the Madrid Gas Company and the consumers of gas in that city. The quality being considered bad and the price (about 4½d. per cubit metre) excessively dear, on the 21st April a meeting was held to settle definitely this question, which has been more or less before the public ever since the year 1878. According to the *Comercio Espaniol*, which gives a full account of the proceedings, an amendment to restrict the use of gas was lost, and a proposal to abstain from the use of gas from the 1st July next was carried unanimously, the committee having reported that all attempts to arrive at an understanding with the company by friendly means had failed. We learn from the *Imparcial* that the committee of the Madrid Mercantile Club, which is arranging the matter in dispute, met again on the 27th ultimo to consider several proposals that had been received in reply to the invitation referred to in our former note. It was decided to publicly test the various methods as soon as possible, and also to wait upon the Alcalde of Madrid, to learn upon what conditions arrangements might be entered into for the use of the electric light. The *Dia* of the 1st instant now states that on the preceding day a deputation waited upon the Alcalde and informed him that from the 1st July next the traders and merchants will discontinue entirely the use of gas, and that from that date the shops and business establishments will be lighted by electric light.

Leeds and the Electric Lighting Bills.—At a recent joint meeting of the Parliamentary and Electric Lighting Committees of the Leeds Corporation, Alderman Emsley presiding, the question of the Electric Lighting Bills, which have been referred to a Select Committee of the House of Lords was discussed. The town clerk, Sir George Morrison, reported as to the action taken by the Association of Municipal Corporations with regard to the Bills, and mentioned that a committee, consisting of representatives of Liverpool, Manchester, Birmingham, Leeds, Nottingham, Sheffield, and Blackburn, had been appointed to deal with the questions affecting Corporations which would arise before the Select Committee. That Committee is appointed to meet on the 10th of May, and it is expected that evidence will first be taken from representatives of the electric lighting companies, and that the committee will sit two days in each week. A deputation to represent the Corporation of Leeds was appointed, consisting of the mayor (Alderman Gaunt), Alderman Emsley (chairman of the Parliamentary Committee), Councillor W. H. Lee Hardwick (chairman of the Electric Lighting Committee), with the town clerk and the borough engineer. It was arranged that the chairman (Alderman Emsley) should bring the Electric Lighting Bills before the next meeting of the council, with a view to the council being asked to petition in favour of the Government Bill, which has been introduced by Lord Houghton.

Alkali Cells.—In a paper in the *Centralblatt für Electrotechnik* (No. 9, 1886) on the "Alkali Element of A. Dun," it is mentioned that this element possesses an E.M.F. which is about as high as that of a Bunsen at the commencement, though it falls off to 1 volt after about half an hour, if the resistance is small, and there remains. But it recovers its E.M.F. after a certain period of rest. This falling off, moreover, is not manifest if the resistance is high, because then diffusion has time to act. The author says, hitherto whenever very powerful, and at the same time time constant cells were required, recourse was usually had to the Bunsen. But, with its good qualities of great E.M.F. and constancy together with small internal resistance, it has the three defects, that the chemical action goes on when the circuit is broken, that it gives out noxious vapours, and that keeping it in working order is both troublesome and expensive. The alkali (or potash) element of Dun is free from all these defects. The negative electrode is a hollow carbon cylinder to which a carbon bottom is left, and the positive electrode is a zinc cylinder. Two thirds of the interior of the carbon cylinder are filled with small pieces of carbon on which is poured acid and permanganate of potash. Two gutta-percha rings prevent contact between the zinc and copper cylinders. It is filled with alkaline solution, which is replenished by putting lumps of caustic potash to dissolve in the glass vessel and carbon cylinder. When the circuit is broken this cell uses no material, whence it may always stand ready for use. The amount of zinc used is exactly proportional to the amount of electricity passed in the circuit. The element is absolutely without smell. It is cheaper to work than a Bunsen element, and it may be used in the neighbourhood of polished metal articles without danger.

The Iron-clad Oath.—In the third annual report just received from the "Bureau of Statistics of Labour," for the State of New York, we find reference made to a document which seems pretty common in America, which is said to generally assume the shape of an agreement to abide by and observe all rules and regulations promulgated by the employers. A violation of any of these rules often subjects the offender not only to the loss of the situation, but also the loss of whatever money may be retained. A specimen of this agreement—which is known among the workmen of the States as the "Iron-clad Oath," as used by the Western Union Telegraph Company—is given on page 587 of the report, and is as follows :—

Western Union Iron-clad Oath.

I .... of .... in consideration of my present re-employment by the Western Union Telegraph Company, hereby promise and agree to and with the said company that I will forthwith abandon any and all membership, connection, or affiliation with any organisation or society, whether secret or open, which in anywise attempts to regulate the conditions of my services or the payment therefor while in the employment now undertaken. I hereby further agree that I will, while in the employ of said company, render good and faithful service to the best of my ability, and will not in anywise renew or re-enter upon any relations or membership whatsoever in or with any such organisation or society.

Dated .... 1883.

Signed ....

Address .... (Seal).

Accepted for the Western Union Telegraph Company.

.... superintendent.

It will be seen that this high-sounding agreement is simply a rather strong-worded agreement not to belong to a union, and to do good service to the employers.

German Edison Company.—We have received an account of the last year's undertakings of this company. The directors say that during this, their third year of business, they have made progress both technically and commercially. They found the demand for electric lighting increase as the installations increased. The severity of the struggle with the gas companies has decreased, and they hope before long that an

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arrangement will be brought about which will unite their common interests. In a few cases they have given in, where competition would have lowered the price below what was necessary to bring them a fair profit. Last year they installed 129 machines for about 22,000 incandescent lamps, and about 500 arc lamps, thus exceeding their performances of the preceding year. They have been occupied principally with the construction of central station work, while other firms have undertaken isolated plants. The company has had the electric lighting of the German theatres almost entirely in their hands, and is to have that of the Friedrich-Wilhelm University in Berlin. They have introduced their arc lamps with great advantage in conjunction with the incandescent lamps. Besides the construction of lamps they also manufacture electrical apparatus and instruments. The rooms of the house at 85, Friedrichstrasse, with the exception of the ground floor, are devoted to the exhibition of electrical apparatus. They have been during the past year in the full enjoyment of all the Edison patents, and of such Maxim and Weston patents as have been acquired and found of service. They have taken out patents to protect their new arc lamps, and also to secure themselves in the use of other inventions. The claim of nullity made by the Swan Company against one of the fundamental Edison patents has been dismissed by the Imperial Patent Office. The Swan Company has also been prevented from selling Swan lamps as infringing an Edison patent by a modification which has been pronounced immaterial.

Electric Light and Telephone Wires in Madrid.—The Madrid papers have lately been discussing alleged defects of the telephone service in that city, one of which was said to be the irregularities caused by the induction from the wires of the electric light which run in close proximity. Not only have the telephonic communications been rendered difficult by the induction, but, according to the *Dia*, accidents have occurred which might have been attended with very serious results, owing to the fact that the wires of the electric light are carried overhead without proper arrangements for insulation. The Madrid papers we have referred to considered the matter sufficiently grave to warrant the special attention of the Telegraph Department, and the interference of the civil authorities with a view to the wires being placed below ground. In reply to the complaints of the *Dia* the director of the "Sociedad Matrileuse de Electricidad" wrote to that paper denying that the electric light wires were insufficiently protected at any point where a contact with the telephone wires was possible. He further asserted that the electric current is conducted below the telephone lines, that the irregularities in the telephonic service must be due to defective instruments and polarisation, and that a breakage of the electric light wires could not result in the alarming state of things alleged in the press. The *Dia*, in answer to this communication, affirms, on the authority of those charged with the installation, that the electric light conductors are unprotected throughout two-thirds of their length, though recently some protection has been afforded at the points where the wires cross each other, and then proceeds to give a detailed list of mishaps that have occurred through the breakages referred to, some of which, it states, have completely destroyed the telephone, the apparatus being carbonised, and some of the screws fused by the current. The *Dia* professes to speak entirely in the public interest, and without *animus*; but it implies that the existence of a formal concession in favour of the Electric Lighting Company in Madrid is questioned by many.

Tungsten and Iron Alloys.—The following investigation, says *Van Nostrand's Magazine*, was made with a view of determining the chemical constitution of the compounds of iron and tungsten, employed in steel making. An alloy of the specific gravity 9·31, containing iron 68·4, tungsten 28·2, and carbon 1·9 per cent., was closely powdered and boiled in hydrochloric acid until the evolution of hydrogen ceased, when the crystalline powder adhering to the surface of the fragments was rubbed off. The metallic powder obtained from several repetitions of the above operation was boiled for several hours in hydrochloric acid, and finally washed with water, boiling potash lye, alcohol, and ether, and heated to redness in a current of hydrogen. The result was about 40 per cent. of metallic residue made up of two alloys, separable by the magnet, while scarcely a trace of tungsten was dissolved. The larger part of this residue—fully 90 per cent.—consisted of light steel-grey grains, perfectly unmagnetic, which are well-formed octahedral crystals, sufficiently hard to scratch glass, but so brittle as to be easily rubbed to powder in an agate mortar. They contain iron from 24 to 31, tungsten 69 to 83, and carbon 1·4 to 1·6 per cent. When heated in the air the powder burns with a glimmering light to a brown, non-magnetic product, which, when heated in hydrogen, is reduced to tungsten iron, the crystals preserving their form. No iron is extracted by boiling hydrochloric acid. In order to compare the behaviour of this iron alloy with those with other metals, a perfectly unmagnetic ferro-manganese, containing iron 35, manganese 57·6, and combined carbon 5·87 per cent., was powdered, and oxidised by heating in the air. This was attended with the production of magnetic oxide of iron rendering the whole of the powder magnetic, and after reduction in hydrogen, metallic iron could be separated by the same means. The effect of tungsten in modifying the chemical properties of iron when diffused through it is very marked. This is the particular alloy under examination was found to be completely unaffected by a solution of chloride of copper. From their microscopic characters, as well as their low specific gravity—3·688—it is evident that the crystals, in spite of their compact appearance, are actually hollow forms enclosing gases. The magnetic portion of the residue is a blackish grey metallic powder, without distinct crystalline character. It contains iron 68·1, tungsten 27·7, and carbon 4·1 per cent. When heated in air it burns, augmenting about 80 per cent. in weight, and remains magnetic. By heating in hydrogen, a tungsten—iron compound—is reproduced, which readily gives up iron by digestion with hydrochloric acid. The same alloys were obtained by boiling hydrochloric acid from a pig iron, containing 23·5 per cent. of tungsten; but the proportion of the magnetic uncrystalline compound is larger than that of the harder tungsten crystals. A highly carburized tungsten steel, containing tungsten 11, manganese 1·49, and carbon 2·15 per cent., gave, on solution in hydrochloric acid, 13·1 per cent. of residue in the form of a fine unmagnetic powder similar in composition to the crystals previously described, while a soft steel, containing tungsten when digested with dilute acid, only left traces of iron containing tungsten. The general conclusion drawn from these experiments is, that tungsten is not actually alloyed with the iron, but exists essentially in a free state diffused through the mass of the softer metal, and preserving its own characteristic properties. The most notable of these, namely, low specific volume, accounts for the circumstance that, in order to produce very hard steel by tungsten, it must be used in considerable quantity, in which respect it is in marked contrast to other hardening agents, such as carbon and phosphorus, which form chemical combinations with iron.

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ELECTRICITY IN 1885.—Dr. W. H. Wahl, in his summary of engineering and industrial progress, made as secretary of the Franklin Institute, says:—"In the field of electricity the past year may record no startling discovery, although substantial advances in certain directions were made. In the department of telegraphy, the Phelps induction system is undoubtedly the most important invention brought out during the past year. This system renders it possible to telegraph to and from a railway train travelling at the highest speed, and it is reasonable to suppose that when its capabilities shall have been fully developed in practice, it will contribute materially to the safety of railway travel. The Harlem River branch of the New York, New Haven, and Hartford Railroad has been equipped with the Phelps apparatus since the early part of the past year, and experts agree in the opinion that its practical working is satisfactory. The year also witnessed substantial progress in perfecting and introducing the Delany synchronous-multiplex system, the Baltimore and Ohio Telegraph Company having placed New York, Philadelphia, and Baltimore in connection by this system. The inventor has likewise made considerable progress in his attempts to adapt the system to the transmission of fac-simile despatches. In telephony, there is little of note to record. . . . In the department of electric lighting, the most noteworthy contribution of the past year was the publication of the results of the tests of the efficiency and life-duration of incandescent lamps, and of the efficiency of dynamo-electric machines, made under the direction of the Franklin Institute. These tests have been pronounced by very competent authority to be more reliable and complete than anything that has yet appeared in any part of the world in relation to the subject under discussion. They demonstrated that decided improvements have been made in the construction of incandescent lamps by which their efficiency and life-duration have been notably increased; and, in respect to the dynamo-electric machine, that this has reached so high an efficiency that but little margin for improvement remains. . . . In the electric transmission of power, the progress of the past year was somewhat more positive. Electric motors for railways have been experimentally tested in a number of American cities—New York, Philadelphia, Baltimore, Cleveland, and elsewhere—the trials of the Daft system of electric locomotion on the elevated railways of New York, and in Baltimore, having attracted wide-spread attention. The New York expements do not appear to have been followed by any direct results. In Baltimore, however, the Daft system has been in actual operation since September 1, 1885, on one of the suburban lines of surface railroad (the Baltimore and Hampden Railway). This road was originally a horse railway, and is a feeder of one of the principal lines of street railway in that city. It is about two miles long. Two Daft motors are in use, each rated at 10 horse-power, and regular hourly trips are made from one terminus to the other. The system is reported to be working satisfactorily. In Cleveland, on the other hand, where the first experimental trials with the electric railway in this country were made, the latest accounts report that the electric system has been abandoned. . . . It is, however, in the department of electro-metallurgy that the most signal advance was achieved during the past year. The invention here refered to is that of the Cowles Brothers, of Cleveland, Ohio. These gentlemen have succeeded in constructing a smelting furnace in which the intense heat of the voltaic arc is applied far more efficiently than has heretofore been found possible, and with which they have succeeded in easily effecting the reduction of the most refractory substances. . . ."

TELEPHONY.—M. Rothen has given in the last number of the *Journal Télégraphique* the following statistics relating to telephony:—

Towns.	No. of Subscribers.	Population.	Population per Subscriber.	Subscription in Francs.
Italy.				
Rome	2,054	300,000	146	174
Milan	925	419,787	454	184
Gênes	915	180,000	197	160
Naples	840	500,000	595	200
Turin	758	252,832	334	186
Florence	686	163,112	238	140
Palerme	440	234,000	532	200
Bologne	400	123,274	308	130
Livourne	346	97,096	281	160
Catane	213	100,000	469	200
Venise	200	132,000	660	200
Padoue	160	66,107	413	150
Messine	138	125,000	906	200
Pise	105	50,341	479	120
Brescia	100	40,499	405	—
Sampierdarena	60	—	—	150
Luxemburg.				
Luxemburg	120	16,679	139	—
Holland.				
Amsterdam	1,195	335,000	280	248
Rotterdam	623	157,500	253	252
La Haye	206	117,000	568	252
Arnhem	133	41,500	312	252
Utrecht	112	70,000	625	252
Dordrecht	87	27,500	316	252
Groningen	73	47,000	644	252
Haarlem	64	38,000	594	252
Portugal.				
Lisbonne	497	223,000	449	—
Oporto	329	110,000	334	—
Russia.				
St. Petersburg	1,100	850,000	773	575
Moscow	650	800,000	1,231	575
Varsovie	600	350,000	683	575
Helsingfors	575	46,000	80	200
Odessa	500	220,000	440	345
Riga	400	135,000	337	345
Abo	250	27,000	108	150
Lodz	200	180,000	900	345
Wasa	150	7,000	47	150
Wiborg	150	18,500	123	150
Uleaborg	140	10,000	71	150
Tammerfors	120	16,000	133	150
Bjorneborg	105	9,000	86	150
Kuopio	100	8,500	85	150
Tavastechus	90	8,500	94	150
Borga	60	4,000	67	150
Kotka	30	3,000	100	150
Jyvaskyla	20	2,500	125	150
Kristinestad	20	2,500	125	150
Lavisa	20	2,500	125	150
Sweden.				
Stockholm	3,825	173,433	45	173,50
Gotheborg	738	76,761	104	167
Malmö	355	33,528	94	173,50
Norköping	199	27,300	132	140
Sundsvall	180	7,000	39	167
Helsingborg	90	10,261	114	173,50
Hernösand	80	4,900	61	111
Lund	76	12,900	170	173,50
Soderhamm	73	6,200	85	174
Landskrona	72	—	—	173,50
Jönköping	55	13,877	252	173,50
Umea	50	2,600	52	111
Uddevalla	42	6,600	157	111
Trelleborg	31	—	—	173,50
Eslof	29	—	—	173,50
Nyland	9	—	—	111

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CORRESPONDENCE.

SELF-INDUCTION OF WIRES.—II.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Not having had an opportunity of revising my letter under the above title on p. 471, April 23, I must correct the following typographical errors. The word "equally," in the 4th line of the 4th paragraph, and also in the 5th line from the end of the 6th paragraph, should be "exactly." The date in the 8th paragraph, where, so far as I remember, I left a blank, should be Jan. 10, 1885, p. 180.

I did not expect to return to the subject, and do so because Prof. Hughes has apparently misunderstood my statements. On p. 495, April 30, he says:—Mr. Oliver Heaviside points out that upon a close examination it will be found that all the effects which I have described are well known to mathematicians, and consequently old." A regard for accuracy compels me to point out that I did not make the statement he credits me with; nor, to avoid any hypercriticism, is the above a correct summary of the many things that I pointed out.

I said, "The discoveries I looked for vanished, for the most part, into thin air. They became well-known facts when put into common language." Observe here my "for the most part" as against Prof. Hughes's "all"; and that I said not a word about mathematicians in the whole letter. An immediate consequence of my statement is another, namely, that some, although a minority, of the results were not well known. There is a material difference between what I said and what Prof. Hughes makes me say. In another place I said that I had "failed to find any departure from the known laws of electromagnetism," and then proceeded to give my reasons for it. This statement includes the well-known facts as well as those which are not well known.

It may be as well that I should illustrate the difference between well-known facts and those that are less known, or only known theoretically. The influence of the form of a thin wire (a linear conductor), and of its length, diameter, conductivity, and inductivity on the phenomena of self-induction is well known. The various relations involved form the A B C of the subject. So are the effects of concentration of the current, and of dividing it, or spreading it out in strips, well known. There is another influence that is well known, that is scarcely touched upon by Prof. Hughes. The self-induction depends upon the distribution of inductivity, that is, in another form, of inductively magnetisable matter, outside the current, as well as in it, in a manner which is quite definite when the magnetic properties of the matter are known.

It is not to be inferred that verifications of well-known facts are of no value—that depends upon circumstances. To be of any use, we must know what we are measuring and verifying. The theory of self and mutual induction in linear circuits is almost a branch of pure mathematics, so simply are the quantities related, and so exactly. It furnishes a most remarkable example of the dependence of complex phenomena on a very small number of independent variables, by ignoring minute dielectric phenomena. In getting verifications, then, it is first necessary to employ a correct method (I have elsewhere, April 30, p. 489, shown the approximate character of Prof. Hughes's method of balancing, and pointed out exact methods). Next, it is necessary to put results in terms of the quantities in the electro-magnetic theory which is founded upon the well-known facts; how else can we know what we are doing, and see how near our verifications go?

Coming now to results that are not well known, there is the thick wire effect, depending on size, conductivity, inductivity, place of return current, &c. This is, in my opinion, the really important part of Prof. Hughes's researches, as it, in some respects, goes beyond what was already experimentally known. Having been, so far as I know, the first to correctly describe (*Electrician*, Jan. 10, 1885, p. 180) the way the current rises in a wire, viz., by diffusion from its boundary, and the consequent approximation, under certain circumstances, to mere surface conduction; and believing Prof. Hughes's researches to furnish experimental verifications of my views, it will be readily understood that I am specially interested in this effect; and I can (in anticipation) return thanks to Prof. Hughes for accurate measures of the same, expressed in an intelligible form, to render a comparison with theory possible if it be practicable. (I send with this a first instalment of my old core investigations applied to a round wire with the current longitudinal.)*

There are also intermediate matters where one can hardly be said to be either making verifications, except roughly, or discoveries; for instance, the self-induction of an iron wire coil. Theory indicates in the plainest manner that the self-induction coefficient will be a much smaller multiple of that of a similar copper wire coil than if the wires were straightened. Magnetic circuits are now getting quite popularly understood, by reason of the commercial importance of the dynamo. But there is really no practical way of carrying out the theory completely, as the mathematical difficulties are so great. Hence, actual measurements of the precise amounts in various cases of magnetic circuits are of value, if they be accompanied by the data necessary for comparisons.

There is, however, this little difficulty in the way when transient currents are employed. Iron, by reason of its high inductivity, is pre-eminently suited for showing the thick wire effect. We may not, therefore, be always measuring what we want, but something else.—Yours, &c.

May 2, 1886. OLIVER HEAVISIDE.

DUPLEX CUT-OUTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to Mr. W. Granger's letter in your last issue, we would beg to say that our specification has been drawn with a full knowledge of all and everything claimed in Mr. K. W. Hedges's specifications of 1881, 1882, 1883, and 1884, and we fail to see any point in which he anticipates our own claims. Our memory does not carry us back to all Mr. Hedges' excellent productions exhibited at the Crystal Palace Exhibition, and failing anything published on the subject, we must plead ignorance as our excuse, *if any is needed*. As you, sir, are doubtless aware, from the specification which we furnished to you, there are many points in our invention which did not and could not appear in the limited space at your disposal for noticing our instrument, but which we thought would (as you so lucidly expressed it) explain themselves.

We have written to Mr. Granger asking for an interview, when we shall be happy to point out to him what are the essential features and claims of our invention, and would ask other subscribers who may feel interested in the subject to either favour us with a call to inspect the "Cut-out," or to consult our specification, No. 14,741 of 1885, which may be found, of course, in the various libraries of the Patent Office.—Yours, &c., BAILY AND GRUNDY.

Amberley Works, Amberley-road, Paddington, W.,
May 5, 1886.

A CLAIM OF PRIORITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: You have heard of Mr. Edison's wonderful discovery of induction telegraphy, and his recent successful experiments in telegraphing from moving railway trains. The newspapers, both of America and Europe, have had much to say of this new electrical marvel. It will be interesting, therefore, to know that Mr. Edison has no real claim to this discovery. He has simply applied another man's patent. William L. Silvey, a young mechanic of Cincinnati, invented the induction telegraph at Castleton, Indiana, nearly five years ago. His patent on the invention bears date July 12, 1881. At the time of making this discovery Mr. Silvey was but nineteen years old. He had no means or influential friends, and was unable to interest anyone in the device. The apparatus was given a test at Indianapolis, but it was regarded then somewhat as a scientific toy without a future. Since Mr. Edison's experiments the commercial value of the device is recognised,

* We hope to give this in our next number.

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although these experiments are no more satisfactory in a scientific point of view than those made by the youthful inventor five years ago. I had the pleasure of meeting Mr. Silvey recently, and found him a modest, industrious young man. He was employed at Lane and Bodley's machine shop, where he was building an electric light dynamo, under his own patent, for the firm.

Noting the advantages of the induction telegraphy over the old system Mr. Silvey said: "There are many advantages. With a small battery we can telegraph long distances. With two quart cups of battery I could easily send a message through a resistance equal to 600 miles of telegraph wire, and it would be produced as loud as any Morse alphabet ever sounded. It would require about 600 cups of battery to send a message the same distance with the Morse sounder and key. Another use would be in sending press despatches. A single operator could have the induction coil of his instrument wound with a number of coils of wire, and by connecting a line with each coil he could send 50 or even 100 messages in as many ways at once. In the telegraph business of railways it would be of incalculable advantage, as may readily be seen. Telegraphing from moving trains is a great achievement, but I believe induction will soon be adopted to purposes of far greater importance to commerce and industry.—Yours, &c., R. W.

Cincinnatti, Ohio, April 19.

ELECTRICITY *VERSUS* HEAT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Thanks for your having published my three letters containing particulars of experiments which prove that electricity and heat are two independent elements.

There is another fact bearing on this subject which is of much practical importance to those who are interested in the passage of electricity through wires. The published writings of the late Mr. Sabine show that in 1883 he had discovered that when a wire was part coated with india rubber and part left bare, and on a current of electricity being passed through this wire, the part coated with india rubber was 25 per cent. cooler than the uncoated part in contact with the air. A Mr. White has recently made similar experiments in America, and it is alleged that he found that when a wire of 65 mils. was part coated with a covering of 285 mils., and a current of electricity passed through this wire, the uncoated part became three times hotter than the coated part. Now every electrician will admit that a wire with a coating of 285 mils. of good insulating material should retain within it more perfectly the current of electricity than the other part of the same wire which was exposed to the air. This being admitted, it becomes manifest that the source of the heat cannot be in the electricity, or else the coated part of the wire would have become the hottest part instead of being the coldest. The explanation of this is through the fact proved by my experiments that electricity has a powerful attraction for heat. The current of electricity while passing through the uncoated part of the wire had free access to the air, and in consequence the electricity within the wire attracted to itself the latent heat of the air, and thereby the wire became hot, whereas the part of the wire coated with the covering of 285 mils. remained cool, because the current of electricity while within that part of the wire was prevented from attracting to itself the heat of the surrounding air, because the covering was interposed. The practical conclusion to be drawn from this is that the covering for wires should be air-tight and non-conducting of heat, as well as being insulating.

This subject has an important bearing on the recent experiments so ably carried out by Prof. Hughes. A copper wire consists of three things—first, molecules of copper; second, latent heat; and third, latent electricity. These three things in the normal state of the wire are all balanced and in a state of rest to one another, but the moment an electrician forces a current of electricity into that wire the balanced state of the aforesaid three things is disturbed. When the forced current of electricity enters one end of the wire it attracts to itself a portion of the heat which had hitherto been at rest within the embrace of the normal electricity of the wire, and hence a new adjustment of the relative positions of the molecules of the copper, of the heat, and of the electricity takes place within the wire, beginning at the anode end and continuing to the cathode end of it. It is during this readjustment of the molecules of the aforesaid three things that the wire is in that which has been called the variable state of it; and after the readjusted or new balanced condition of the three things has taken place the wire is then in that which is called the stable state.—Yours, &c. JAMES JOHNSTONE.

8, Merchiston-park, Edinburgh, 3rd May, 1886.

ERRATUM.—Dr. Romain Vigouroux writes, in reference to his letter in our last issue, to point out that *e* was substituted for the *o* in the last syllable of his name; and that the Trouvé battery to which he refers is not formed of *fluid* but of *moistened* elements, *i.e.*, is constructed with blotting paper saturated with sulphate of copper solution.

OBITUARY.

THE LATE L. H. F. MELSENS.

LOUIS HENRI FRÉDÉRIC MELSENS, a true *savan*, as distinguished as he was unassuming, has passed away. Though eminent in all branches of physical science, he will chiefly be identified with the system of lightning conductor—of large sectional area terminating above in numerous points, and connected below with a considerable surface in contact with damp earth or water—which he applied to the Hotel de Ville and the Palais de Justice, Brussels. He was Professor *emeritus* of the Belgian Veterinary College, Permanent Examiner at the Ecole Militaire, Gas Verificator to the Brussels Municipality, Member of the Belgian Royal Academies of Science and of Medicine, and also of many other scientific societies in Belgium and other countries, Commander in the Order of Leopold, and Chevalier in the Legions of Honour of Gustavus Vasa and Francis Joseph. He was awarded a prize by the French Institute for his discovery of the therapeutical properties of iodide of potassium, one only of his many chemical discoveries. Melsens died in harness.

In his 72nd year M. Melsens was working hard at the almost hopeless attempt to collate his many papers and notes; and he bitterly lamented the want of time to keep pace with scientific discovery. "Chemistry has now twenty branches," he remarked sorrowfully to a Belgian contemporary, "and a whole life is necessary for becoming conversant with one." The early part of Melsens' career was a hard struggle, for he was bent on devoting himself to scientific pursuit. His whole existence was one of thorough and painstaking research, not for glory, but for the love of it and for the benefit of mankind. He received a sad blow a few years ago by the death of an only daughter, who was about to be married; and, though every effort was made by his devoted spouse to rouse him from his melancholy, there is little doubt but that his useful life has been shortened in consequence. At the Military College Melsens was the terror of candidates for examination, whom he turned inside out to discover whether they were worth anything or not. He was, however, not only respected but beloved by both pupils and professors, and indeed by all who had the honour of his acquaintance. Melsens was born at Louvain on the 11th July, 1814, and died at Brussels on the 20th April, 1886, after a short but painful illness. He was buried at the Evere Cemetery in presence of a large concourse representing the various bodies with which he had been connected.

Four funeral orations were pronounced over his grave by M. Wehenkel, director of the Veterinary College; M. Leserre, Commandant of the Ecole Militaire; M. Mailly, director of the scientific section of the Belgian Royal Academy; and M. Warlomont, president of the Belgian Royal Academy of Medicine.

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THE ELECTRICIAN.

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Advertisements intended for the current week's issue must be handed in not later than Thursday, 4 p.m.

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With this number a Supplement is issued (Gratis), containing the Index to Vol. XVI. This Supplement should be received with every copy of the paper. Complaints of non-receipt should be forwarded to the Manager.

LETTERS.

A letter awaits G. W.

GAS AND ELECTRICITY.

Now that there is a prospect of free play for electric lighting enterprise, by the removal of those legislative restrictions which have hampered it during the past three years, the gas interests appear to have taken fright, and are doing their best by disparagement and misrepresentation to damage its rival in the business market. At least this is the natural inference to be drawn from recent animadversions in a certain section of the press usually identified with what are called vested interests. So far as these efforts are directed to warn the owners of gas property against a recurrence of the absurd panic which overtook them four or five years ago we are in entire sympathy with their object. We have never encouraged the idea that electricity was going to supersede gas all at once, or to lessen its business in an appreciable degree for a long time to come. Nor are we disposed to do so now, even though the improvements in the several branches of electric light engineering in the meanwhile have been so numerous and important that a more sanguine view of the new industry and a less hopeful one of the old would seem to be justified. What we have all along asserted, and what we repeat now with more confidence than ever, is that the electric light has its own peculiar sphere of usefulness, and a very wide sphere, quite apart from its competition with the older illuminant; and, secondly, that if electricity were allowed to compete on equal terms it would in many departments of life provide an agreeable light where gas is unacceptable, and in some others would thrust gas out of the field altogether.

To be candid, we think that in respect to the last-named field of operations electricity has a far better chance of success than its enemies seem to suppose, and that it will not be very long delayed. But for all that we do not in the least share their apprehensions as to the fatal consequences to gas property. Certainly there have been no grounds for such apprehension so far; and this not because electric lighting has made no progress, but because the demand for a better light created by the conspicuous superiority of electricity has given rise to a greater consumption of light all round, for which gas has furnished a very considerable quota. This effect will operate so long as the two systems are in a state of healthy competition; and will further tell for the benefit of gas manufacturers in the demand for gas engines, which are peculiarly adapted for some kinds of electric lighting installations. The high prices which gas property still maintains in the market, and the undiminished dividends it continues to pay show that there has been no falling off in the consumption of gas, or any slackening in the normal increase of consumption which has gone on hitherto year after year. There are, in fact, good grounds for suspecting that the GAS COMPANIES have profited largely by the advent of electric lighting. Certainly this is the case in the metropolis, and we have heard of no instance in the provinces where the effect upon gas property has been otherwise than beneficial.

The advantage to the public has been of course very great. Never have our main thoroughfares been so well lighted as they are at present, nor has there ever been such attention paid to considerations of public safety as has been the case under the stimulus afforded by the rivalry of the electric light. New gas burners have been invented which, whatever other merits they possess, have one that must commend them to the companies—the consumption of gas is on a scale proportionate to the magnificence of their illuminating power. We have not yet met with any invention that economises gas, though we hear of a great many. The universal tendency is towards profuse illumination, at all events out of doors, and undoubtedly gas interests have not suffered on that account; indeed, it has been spitefully observed in many quarters that the main consequence of a partial introduction of electric light has been to swell the bills for gas light. It is one consequence, no doubt; but another and more far-reaching effect is the one to which we have already adverted, namely, the creation of a standard of street lighting which the public will insist upon being maintained. And to some extent this remark applies to indoor lighting as well—at all events in large places of public assemblage. The electric light is firmly establishing itself in this direction, not perhaps rapidly, in superseding gas where gas has always been used, but in new buildings, and even in old ones where the change can be effected without serious loss. And in respect to indoor lighting, the demand is not only for a better but for a more wholesome and agreeable light. We may confidently predict, therefore, that the light of the future will be better, far better, than it has been under the undisturbed supremacy of gas; and that it will have to be purer and healthier than gas is ever likely to be.

Here the question arises, what are the probable consequences to gas and electricity which this state of things seems to foreshadow? So far as gas is concerned, we may leave it to take care of itself. Whenever the income of the gas companies is seriously imperilled they will not be slow to incorporate the new illuminant in their general system rather than see the business of supplying light pass gradually into other hands.

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So far as we are concerned, the electric light will be as welcome whether supplied by a gas company or by a company exclusively devoted to electricity. But, occupying this impartial position, we feel ourselves entitled to warn the gas companies against their ignorant friends in the press, who talk as if the electric light had been tried and had failed in every particular. A city contemporary has just been treating the subject of "Gas and its Opponents" as if the electric light were slain already, and paraffin oil only living on sufferance. The production of electricity, says the *Citizen*, is as costly now as it was ten years ago, and is as uncertain and as troublesome; no improvements have been devised for its production or distribution, and its prospects are as gloomy as ever. Now, this kind of talk is unsafe as well as untrue. We are not "opponents" of gas; nobody that we know of is an opponent of gas; we are friendly to electric lighting, as every sane man is, when and where it can be had with proved advantage over gas, for its superior light and its infinitely preferable salubrity.

We prefer to enjoy our evening, for example, at such theatres as the Savoy or the Prince's, and to dine in comfort at such restaurants as the Holborn, not because we dislike gas, as an illuminant, but because we do not like it for dinner, or in the place of fresh air. And as regards open places and street lighting, we are content with the light that really does what it professes to do, and is at the same time not over costly. Our contemporary says as to this that the electric light is too expensive. Three years ago the same would have been said of those almost too gorgeous street gas lamps which electricity has frightened into being in such great abundance. We should like to know what they cost to erect, and what to maintain. They are expensive undoubtedly, but the public will have them or something as good or better; and what we say in this relation is, if it be the case, as we suspect it is, that electricity would be the cheaper illuminant, gas will sooner or later have to give way for it, even in the streets.

BLOCK SYSTEMS IN EUROPE AND AMERICA.

In Europe, according to a review in the *Bulletin* de la Societé Belge des Electriciens, the systems are not nearly so automatic as in America, owing to the lower price of labour, together with the fact that a thoroughly trustworthy pedal has not yet been invented. In the European systems the pedal does little more than call the attention of the signalman to the passing of the trains. In America they have not waited to find a perfect pedal before adopting automatic systems of blocking.

In the Roussean system each post carries a signal connected with two electric contacts (Fig. 1). In making the first contact

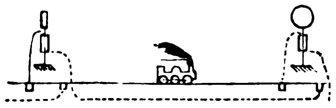

FIG. 1.

by passing over it, the train puts down the signal of the post and thus blocks itself. In making the second contact, it restores the signal of the preceding post, and thus unblocks the preceding section. The contact is produced by a piston placed in a vertical india rubber cylinder under the rail.

In the system of the Union Electric Signal Company each rail of a section forms a conductor insulated from the corresponding rail of the next section. At one extremity of the section there is an electric battery whose poles are connected one with each rail. At the other extremity of the section is the post bearing the signal, which is held up by magnetic attraction as long as the circuit is closed (Fig. 2). An interruption or great diminution of the current puts the signal down. When a train passes along the section, it closes the battery circuit by a small resistance, so that little of the current goes through the magnet, and the signal goes down.

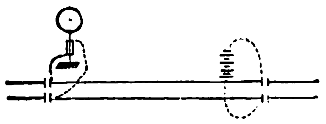

FIG. 2.

Hadden's system is used on the Pennsylvania Railroad and on the Chicago, Burlington, and Quincy Railroad. The electric system is connected by wires. There are two sets of signals, one on each side of the railway. Fig. 3 shows one set of two, one at each extremity of the section. When the armatures of the magnets are attracted, the signals are up; when a train enters a section and closes B′, the circuit is already closed by such a resistance that the current is not sufficiently affected to bring down the signal, the resistance of the secondary circuit thus made being the same as that of the principal one. When the train passes A it momentarily

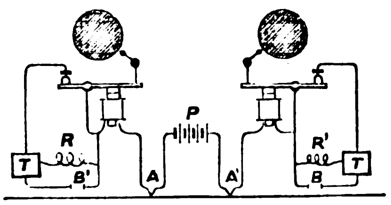

FIG. 3.

breaks the circuit, the magnets let go their armatures, and the signals fall. This action introduces a resistance in the circuit, which renders the current so feeble that it cannot again raise the armatures, and the signals remain down when the circuit is again made. Thus the signals are down at both ends of the section in which the train is. When the train passes A no effect is produced, but on passing B the current is restored, the signals go up, and remain so, since the rise of the signals removes the resistance.

NUMBER OF POLES AT THE SURFACE OF A MAGNETIC BODY.

In a note by M. Stielties, presented to the Academie des Sciences by M. Hermite at the meeting of April 5th, 1886, the author says:—The remark due to Gauss, that the existence of two north poles on the earth's surface necessitated that of a neuter pole, has been generalised by M. Betti (Teorica della forza Newtoniane). In considering a magnetic body bounded by a closed surface simply connected, he demonstrates that the whole number of poles is even.

The most simple method of treating this question has been given by M. Reech in an article inserted in the *Cahier XXXVII. du Journal de l'Ecole Polytechnique*. The author considers specially the maxima and minima of the function $\sqrt{x^2+y^2+z^2}$ at the surface of a body, but the reasoning is general, and, in applying it to the case of a magnetic body, the result of M. Reech consists in that the total number of neuter poles is surpassed by *two* units by the whole number of the other poles. This result includes the proposition of M. Betti.

By slightly modifying the reasoning of M. Reech, one can also treat by this method the case where the closed surface which limits the body is connected $2k+1$ times. One then finds that in general the number of neuter poles diminished by the number of other poles is equal to $2k-2$. As there is always at least one south and one north pole, it follows that the number of neuter poles is at least equal to $2k$.

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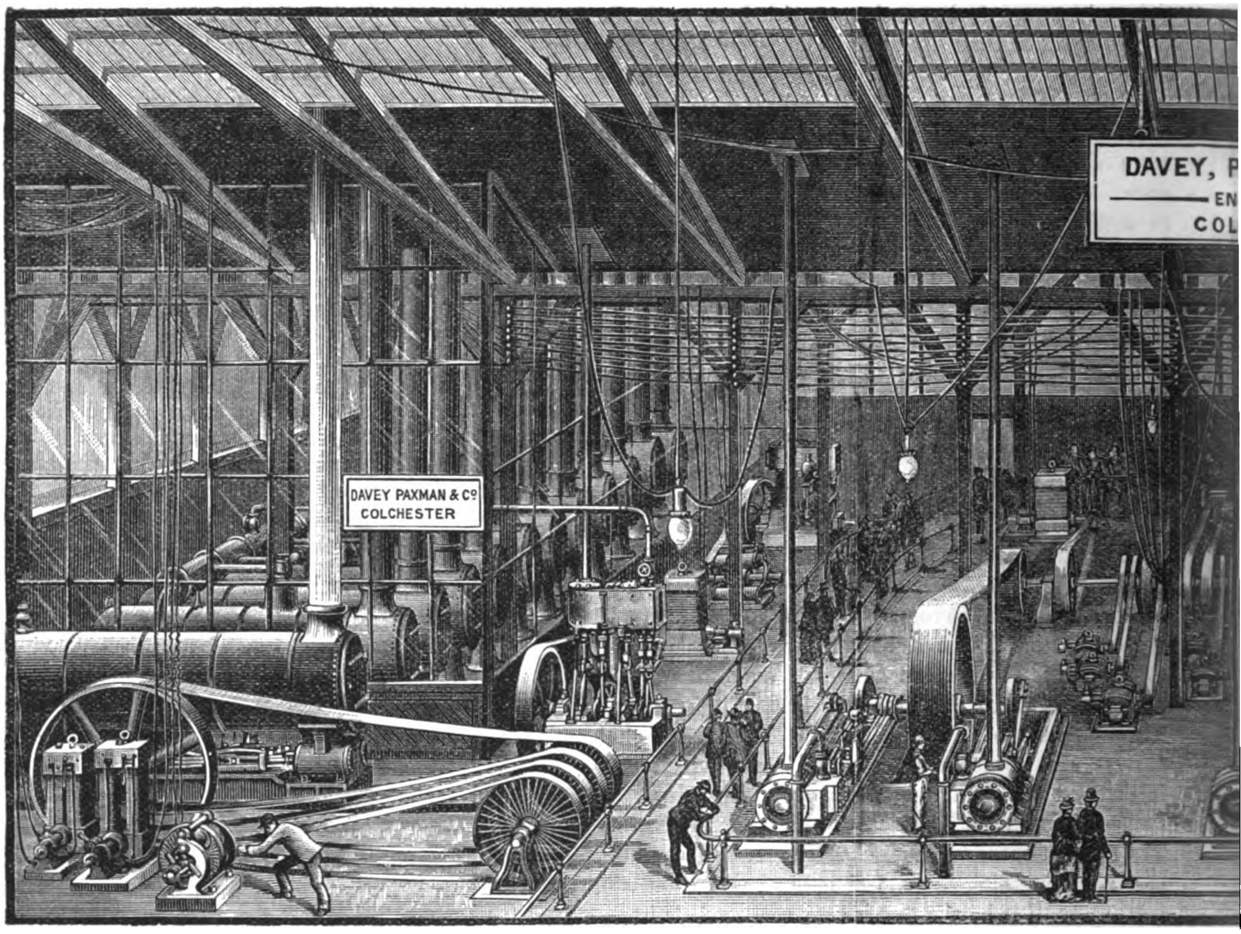
ELECTRIC LIGHT MACHINERY SHED AT THE



On Tuesday last, as most of our readers are aware, the Queen officially opened this year's Exhibition. We are not so much interested with the exhibits generally as with the lighting. Last year we were able to give an illustration of the arrangement of boilers, engines, and dynamos in the machinery shed—to be found in our issue of May 9th, 1885. We give a similar illustration now, and by comparison it will be seen that considerable alterations have been effected, making, in our estimation, this department far more presentable than at any other previous Exhibition. The firm of Messrs. Davey, Paxman and Co., of Colchester, who have supplied the engine and boiler power necessary for working the whole of the vast system of electric lighting throughout the late Inventions, Health, and Fisheries Exhibitions have again been retained for a similar service at the present Exhibition. Their machinery is completed, and amounts to 1,200 horse-power, and is supplied as follows:—No. 1 engine is a compound semi-fixed engine placed beneath the boiler, and capable of developing 120 horse-power; the two largest engines, Nos. 2 and 6, are of the coupled horizontal high pressure type, and capable of developing 700 horse-power if required. Fixed between these are three compound engines, Nos. 3, 4, and 5, No. 3 being on the coupled compound girder system, whilst Nos. 4 and 5 are of the horizontal compound receiver type; Nos. 7 and 8 are new vertical compound quick-speed engines, which can be employed for driving dynamos either direct or otherwise; No. 9 is a small quick-speed vertical engine, driving the dynamo on an entirely new system. All the above engines are provided with Paxman's patent automatic cut-off gear worked direct from the governors so as to ensure very steady and even running. The advantage of this system is that only just sufficient steam required for the duty is admitted to the cylinder at each stroke of the piston. This is one of the very few automatic arrangements which work with regularity and certainty. The cylinders are steam jacketed. It may be mentioned that at the Health Exhibition, 1884, one of the large driving bands on one of the engines suddenly broke, when the engine was transmitting about 350 horse-power; but the excellence of the automatic gear, even in this extreme case, prevented the engine from over-running. Steam is supplied to the semi-fixed engine by its own boiler, while that for the remaining engines is generated in eleven steel boilers of the locomotive type, each containing 610 square feet of heating surface, and working at 120lb. steam pressure. The fire boxes are of Davey, Paxman and Co.'s improved mild steel, which has given such excellent results. Above the boilers is placed a wrought-iron receiver so as to ensure perfectly dry steam. In addition to the above, Messrs. Davey, Paxman and Co. have an eight horse-power horizontal engine driving stamps for extracting gold from ore in a building erected by the Queensland Commission on the south promenade, also a four horse-power "Standard" vertical engine driving one of Paxman's patent safety machines for extracting from the soil diamonds and other precious stones. This machinery is in the South African Court. The steam for these two engines is supplied from Davey, Paxman and Co.'s range of boilers in the electric light shed.

From the notes given in the official guide book we get the following information about the lighting:—"The 'Old London' Street remains substantially as in previous years, the shops on the ground floor being utilised as offices for the various Colonial Commissioners, and the upper apartments reserved as reading and writing rooms, &c. The Central Railway Offices of the Royal Commission are contained in the houses opposite the Church Tower. The Colonial and Indian Exchange Rooms occupy the space forming the entrance to the narrow lane. The street is lighted at night by electricity, and novel and interesting effects, to give the appearance of moonlight, are introduced. On entering the buildings in the evening, visitors will miss the myriads of little star-like lamps which

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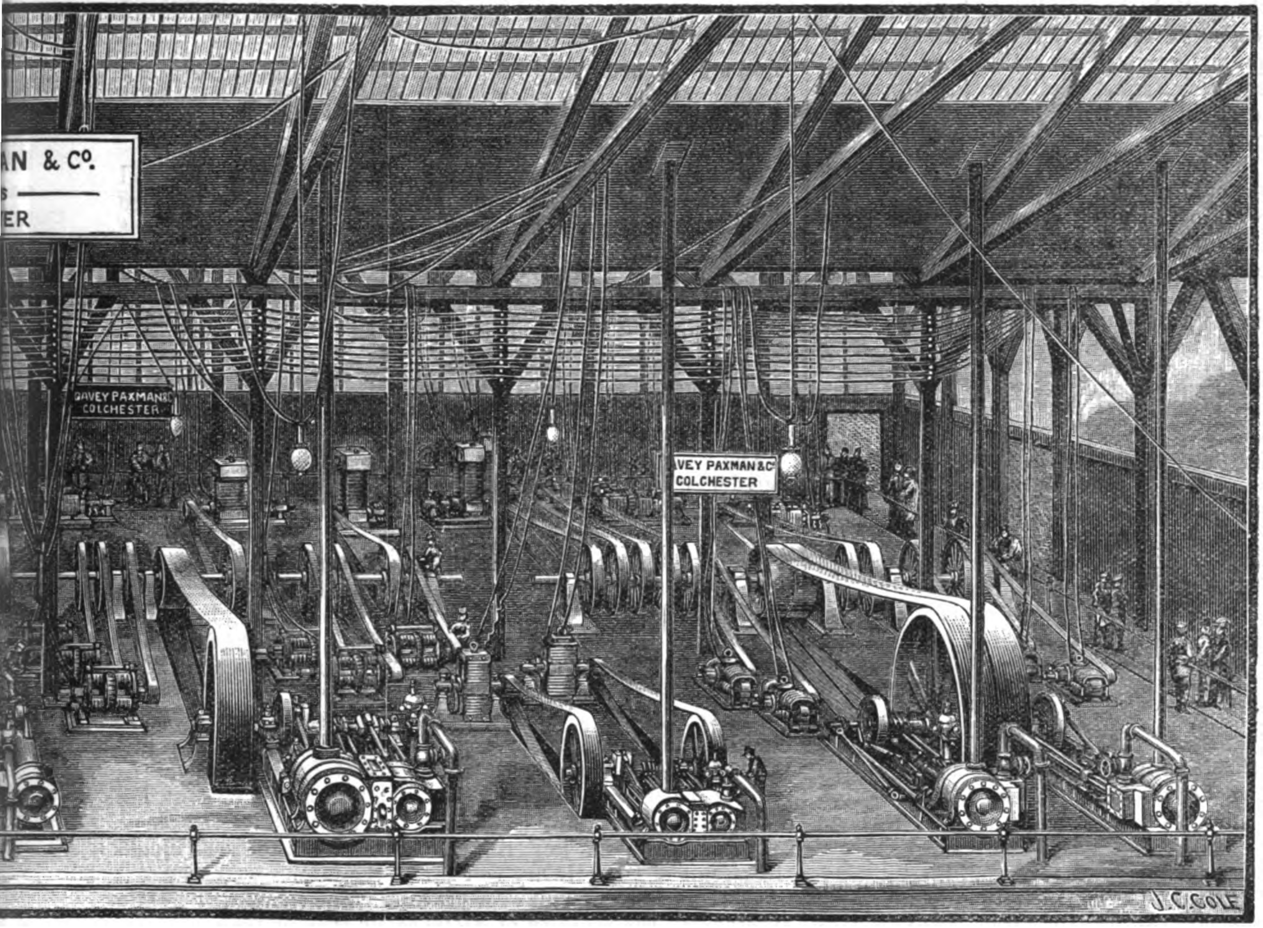
COLONIAL AND INDIAN EXHIBITION.



formerly met the gaze in the southern galleries, and will find in their place fewer but more powerful arc lamps. The whole of the electric lighting is under the control of a committee composed of Sir Frederick Abel, chairman; Sir Francis Bolton, who directs the garden illuminations; and Mr. W. H. Preece, F.R.S., who specially looks after the lighting of the buildings. The motive power required for the internal lighting is supplied under contract by Messrs. Davey, Paxman and Co., of Colchester; the power absorbed amounts to 1,200 indicated horse-power. The principal galleries and courts are lighted by arc lamps, of which 160 are supplied by the Anglo-American Brush Electric Light Corporation (Limited); 140 by Messrs. R. E. Crompton and Co.; and 100 by the Pilsen-Jöel Electric Light Company (Limited)—making 400 lamps in all, each lamp giving a light equal to at least 1,000 standard candles. The Indian Palace, the dining rooms, and the different offices in the 'Old London' Street, as well as the Colonial and Indian tea houses, are lighted by means of incandescent lamps, supplied with current by the Edison-Hopkinson dynamo machines. These machines are lent by the Edison-Swan United Electric Light Company (Limited). The club dining rooms, over the West Arcade; the Chinese Pavilion, the Royal Box, underneath the clock tower; the executive offices, and the subway to the South Kensington Station, are lighted by incandescent lamps, which are fed by secondary batteries, lent by the Electrical Power Storage Company (Limited). These secondary batteries are charged by Edison-Hopkinson dynamo machines. The electric illumination of the gardens will be effected by means of about 20,000 small glow lamps (mostly of 10 candle-power each); and, in addition, a number of arc lamps suspended from tall masts will be used to give a strong moon-like effect when the illuminated fountains are not playing. This installation, as well as the whole of the work connected with the fountains, which have been enlarged and altered, has been carried out by Messrs. Galloway and Sons, of Knott Mill Iron Works, Manchester."

THE FORTHCOMING MARRIAGE OF THE CROWN PRINCE OF PORTUGAL.

A novel apparatus has recently been constructed by Messrs. Merryweather and Sons for exhibition at Lisbon, on the occasion of the wedding of the Crown Prince of Portugal this month.

It consists of a complete set of portable fountains, the water being supplied by two steam fire engines, and the jets will be illuminated at night by powerful electric lights placed underneath, the effect being similar to that which delighted so many thousands at the Inventions Exhibition last year.

The lighting part of the arrangement is undertaken by Messrs. Siemens Brothers and Co., who supply powerful dynamos and engines for the purpose, similar to those at the Indian and Colonial Exhibition.

The pipes forming the fountains are self-contained in the frame. Five large jets are thrown, either in plain streams or by means of an ingenious arrangement. These may be instantly changed into inverted cones of spray. Around the centre jet are arranged four nozzles, throwing fine spray.

The engines are Merryweather and Sons' well-known direct-acting type, as used in the London and other fire brigades, and are connected to the fountains by means of flexible leather hose.

The fountains will be fixed in a barge moored in the Tagus, the engines being placed in another boat, and the display will be carried out by engineers expressly sent out from this country by the makers of the apparatus.

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THE EDISON "PHONOPLEX" OR "WAY-DUPLEX."

While the duplexing of through telegraph lines is now an easy matter and largely applied, the problem of increasing the capacity of lines employed in way service, such as upon railroads, has up to the present received no satisfactory solution. The ordinary duplex requires a fixed condition of the line, and when that varies even slightly it must be compensated for. Evidently, with twenty or thirty stations on a railroad line, or ordinary way offices, the communication with each office on the usual duplex plan would require a separate balancing for each one, and as one office is called up after another there would be a constant changing and loss of time. Besides, the ordinary duplex would not permit of two independent offices communicating with one or two other offices, and hence its value would be greatly restricted; indeed, its successful application would be well nigh impossible.

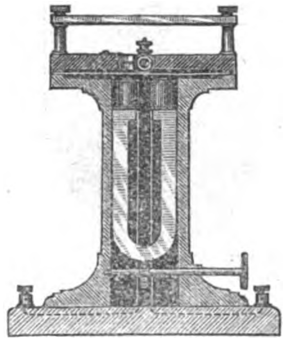

Fig. 1.—The Edison "Phonoplex"—The "Phone."

With these drawbacks in mind, Mr. Edison has devised a most ingenious method of doubling the capacity of telegraph lines, whether employed on way business or through traffic.

The name which he has given to the system, the "Phonoplex," or "Way-duplex," suggests immediately an application of the telephone, and such is indeed the case.

circuit a telegraph relay and a telephone, we may, by manipulating a key, operate the relay (and sounder) without producing a sound in the telephone, as the makes and breaks at the key are too gradual. But if through the same circuit we send the rapid discharge current from the secondary of an induction coil, or the extra current from a primary, it will cause a loud click in the telephone, but the current is too weak to affect the telegraph relay. Hence, by sending two kinds of currents over the wire, we obtain two effects which can be readily utilised for the purpose above described.

There are, of course, several points which must be observed in practice, and these have been well worked out, as will be seen in the diagram Fig. 2, which represents the equipment and arrangement of circuits in each office. The whole may for convenience be divided into the Morse and the "Phone" branch, although in reality there is no branch, as in the ordinary duplex, the line being continuous through both.

The Morse circuit at the left consists of the ordinary relay R, sounder S, and key K. In addition, however, there is a condenser C, placed as a shunt around the relay and key, the function of which will appear presently.

The "phone" circuit shown at the right contains the phone-sounder, with permanent magnet M, diaphragm D, and will be described more in detail below. The phone local battery P L B is in circuit with the primary coil I, which is always included in the line circuit, and also has a condenser C′ connected to its terminals. The circuit coming from one terminal of the coil I is split, one branch going directly to the back stop of the relay R′, and the other to the front stop, but including a variable resistance R″. The phone operator manipulates the key K′ as usual.

For the sake of clearness, we will suppose that the Morse circuit is not at work. The circuit would then be from line through the phone, thence through coil I, through key K, relay R, battery and earth. But in addition the current has a by-pass through the condenser C. Now, when the phone operator closes his key K′, the lever of the relay R′ breaks the circuit of the primary coil I, and the intense extra current of short duration is sent over the line. The effect of the extra current and the rapidity of discharge is still further increased

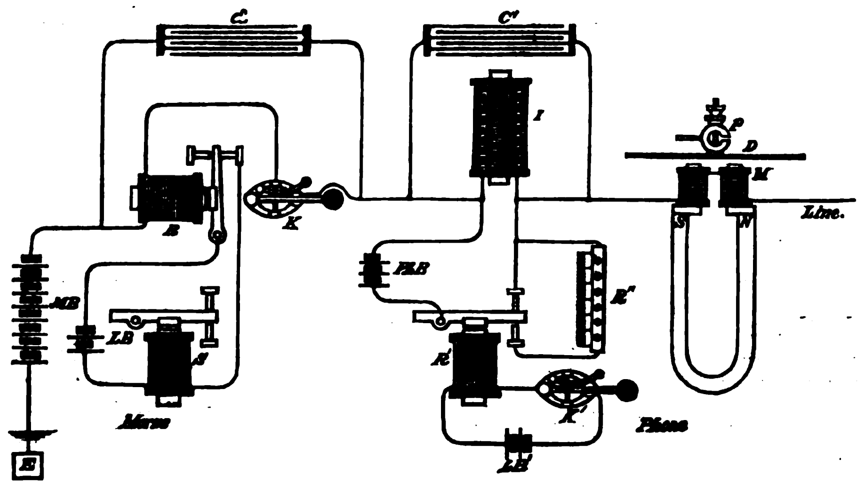

Fig. 2.—The Edison "Phonoplex"—Equipment and Arrangement of Circuits in each Office.

While Mr. Edison's method of working is analogous to that of Van Rysselberghe in his system of simultaneous telegraphy and telephony over the same wire, he, nevertheless, has an entirely different object in view, and that is, to convert the telephone on the circuit into a sounder, so that the regular Morse can be read from it.

Before entering into a description of the details, it may be well to give a short outline of the principle employed.

It is well known that if the emission and extinction of the current in the telephone be gradual, the diaphragm will be merely bent, and will return to its original form without emitting a sound. But if the make and break in the current be rapid, the telephone diaphragm will "snap," and so give forth audible sound. If now there are included in the same

by the condenser C′, which is placed there for that object. This intense and rapid extra current does not affect the relays on the line, but passing through the condenser C, acts powerfully on the diaphragms of the phones and gives a violent motion to the snapper P.

It will be noticed that every movement of the lever of the relay R′ sends two impulses over the line—one on breaking the circuit and another on making at the front stop. The extra current produced by the latter, however, is greatly diminished by the resistance R″, and follows so quickly upon the first that there is but one click heard in the phone. When the armature lever of the relay R′ is released by the raising of K′, the reverse operation takes place, for we then have first a weak extra current over the line followed by a stronger one. This change

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in the order of the currents causes a difference in the sound emitted by the phone, just as in the ordinary sounder the sound of the front stroke differs from that of the back stroke. In this way the signals received in the phone can be clearly distinguished.

Thus far we have supposed that the Morse operator is not working. From what has gone before, however, it is evident that it makes no difference whether his key is closed or not, as the condenser C is all sufficient for the transmission of the high potential phone current.

In additional to the gradual emission of the Morse current which the operator's key produces, there is also added thereto the retarding influences of the relays in circuit and the primary coils I, which then have the same functions as when applied to the Van Rysselberghe system, in which they act as "graduators." While offering no resistance in speed to the Morse working, they "graduate" the emission of Morse currents so that they merely deflect the diaphragms of the "phones" without snapping them and producing a sound.

Though a variable resistance, R″, is used, it is merely for the purpose of varying the sound in the "phone" to suit the operator's ear, and once set is never disturbed.

The "phone" itself is a simple and ingenious apparatus, and is shown in section in Fig. 1. Resting upon a wooden base is a hollow column of brass, within which is placed a magnet with the bobbins facing the diaphragm. At the lower end of the magnet there is a rack and pinion, by which it can be adjusted with reference to the diaphragm. To the centre of the latter there is attached a screw-threaded pin, with thumb-nut and binder at the top. Encircling the pin loosely is a split-hardened steel ring which rests upon the diaphragm. When the latter is snapped by the attraction of the momentary current in the magnet, it throws the ring violently against the stop-nuts, and produces a sharp click, far louder than that from the ordinary sounder. The steel ring has a pin projecting from its side that passes between two prongs, which, while permitting free up and down motion, prevent the ring from turning and altering the sound. Over the top of the "phone" there is clamped a thin brass plate as a protection for the projecting screw.

This phonoplex system is especially valuable for railway telegraphy, but is equally well adapted for regular lines, and is already in operation in various places. Several city lines in this city are equipped with it, and the Baltimore and Ohio Telegraph Company and Railroad have it in operation between Baltimore, Harrisburg, and Pittsburgh.

The "phone" local battery only requires three or four cells for the longest distances, say two or three hundred miles. As stated before, the operation of the system is extremely simple, and the condition and length of the line has no effect upon the working. We believe that the system is destined to a rapid spread. Its simplicity is one of the strongest points in its favour.—*Electrical World.*

ELECTRICAL THEORIES.

BY PROF. J. J. THOMSON, M.A., F.R.S.

(Continued from page 500.)

If we regard the whole electric field as a dynamical system, and to fix our ideas consider an element a of the dielectric, and the current, which is supposed to vary, then, since a variation in the current polarises a, *i.e.*, produces a change in its structure, there must be mechanism connecting the current with the element a; but if this is so then it follows from dynamical principles that a non-uniform variation in the structure of a must produce a change in the current—in other words, that a change in the rate of change of the polarisation of a produces an electromotive force on the current, *i.e.*, that the change of polarisation produces an effect analogous to that of an ordinary conduction current. We may illustrate this by a purely dynamical example. Suppose we have a dynamical system defined by two co-ordinates p and q, and let T be the kinetic energy of the system and V the potential energy; then by Lagrange's equation the force tending to increase q

$$= -\frac{dV}{dq} + \frac{dT}{dq} - \frac{d}{dt}\frac{dT}{d\dot{q}}.$$

Now, if there is a force tending to alter q which depends upon the acceleration of p, there must be a term in the kinetic energy of the form

$$A\ddot{p}q;$$

but if we apply Lagrange's equations to the p co-ordinates we see that this term implies the existence of a force tending to increase p equal to

$$-\frac{d}{dt}A\dot{q},$$

so that an acceleration of q will produce a force tending to alter p. To make this applicable to the case of the current and the dielectric, we have only to suppose that $\dot{p}$ represents the current, q the polarisation of the dielectric. That a change in $\dot{p}$ produces a change in q is shown by the fact that the dielectric is polarised when the current is changing, and this shows that there must be a term of the form $A\dot{p}q$, in expression for the kinetic energy; from this it follows that a change in $\dot{q}$, *i.e.* in the rate of change of the polarisation, will produce an E.M.F. on the circuit. As the variation of the dielectric polarisation produces the same effect as a conduction current, we must in the case, when both conduction current and alteration in the polarisation are present, look upon the true or effective current as the sum of the conduction current and the change in the polarisation.

The components f, g, h of the dielectric polarisation are defined by the equation

$$f = \frac{K}{4\pi}X, \qquad g = \frac{K}{4\pi}Y, \qquad h = \frac{K}{4\pi}Z,$$

where K is the specific inductive capacity of the medium, X, Y, Z the components of the electromotive force. If u, v, w are the components of the effective current, p, q, r the components of the conduction current, then Maxwell in his paper on a "Dynamical Theory of the Electromagnetic Field," *Phil. Trans.*, 1885, puts

$$u = p + \frac{df}{dt}, \qquad v = q + \frac{dg}{dt}, \qquad w = r + \frac{dh}{dt}.$$

Since $$\frac{dp}{dx} + \frac{dq}{dy} + \frac{dr}{dz} = -\frac{d\rho}{dt}$$

and $$\frac{df}{dx} + \frac{dg}{dy} + \frac{dh}{dz} = \rho,$$

where ρ is the volume density of the free electricity, we see that

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0.$$

If the values of the quantities in a medium A be denoted by putting the suffix 1 to the symbols representing them, and those in another dielectric B by putting the suffix 2, then if l, m, n are the direction cosines of the normal from A to B, we have at the boundary of the two media

$$l(p_1 - p_2) + m(q_1 - q_2) + n(r_1 - r_2) = \frac{d\sigma}{dt}$$

$$l(f_1 - f_2) + m(g_1 - g_2) + n(h_1 - h_2) = -\sigma,$$

where σ is the surface density of the electricity; thus

$$l(u_1 - u_2) + m(v_1 - v_2) + n(w_1 - w_2) = 0;$$

so that u, v, w satisfy the same equations as the components of the velocity of an incompressible fluid.

This assumption about the magnitude of the effects produced by the alteration in the dielectric polarisation makes the mathematics of the theory as simple as possible. If Maxwell had merely assumed that the alteration of the dielectric polarisation produces effects analogous to those produced by ordinary conduction currents, and that the equivalent conduction current was proportional to the rate of alteration of the dielectric polarisation, then these equations would have been

$$u = p + a\frac{dX}{dt}, \quad v = q + a\frac{dY}{dt}, \quad w = r + a\frac{dZ}{dt};$$

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so that in a homogeneous dielectric

$$\frac{du}{dx}+\frac{dv}{dy}+\frac{dw}{dz}=-\frac{d\rho}{dt}\left\{1-4\frac{a\pi}{k}\right\},$$

$$l(u_1-u_2)+m(v_1-v_2)+n(w_1-w_2)=\frac{d\sigma}{dt}+a_1\frac{dN_1}{dt}-a_2\frac{dN_2}{dt}$$

where N is the component of the electromotive force normal to the surface.

Maxwell's assumption is that $a=K/4\pi$, and this makes the equations much simpler; it is, however, important to remember that Maxwell's theory of the dielectric involves the two assumptions—

1st. That alterations in the dielectric polarisation produce effects analagous to those of ordinary conduction currents;

2nd. That the magnitude of the equivalent conducting current $=d\left\{\frac{K}{4\pi}F\right\}/dt$, where F is the electromotive force at the point; this is equivalent to saying that all the currents are closed currents, and that there is no discontinuity in them.

Maxwell develops his theory by means of the principle of the Conservation of Energy.

Let us consider an electric field full of currents, whether ordinary conduction currents or polarisation ones. Then this field may be looked upon as a material system, and all the phenomena have to be explained as the effects of the motion of this system; a current must be looked upon as a change in the structure of the system, and so capable of representation by means of the differential coefficients of the co-ordinates fixing the system; we can thus represent the current at each point as the differential coefficient of some generalised co ordinate fixing the system; the components u, v, w of the current passing through an element dx, dy, dz may be looked upon as the rates of change of some generalised co-ordinates; we may write the energy as

$$\tfrac{1}{2}\iiint\{Fu+Gv+Hw\}\,dx\,dy\,dz,$$

where F, G, H may be looked upon as momenta corresponding to u, v, w. It remains to identify F, G, H with known quantities. Maxwell does this by the aid of Faraday's result, that the electromotive force round a circuit equals the rate of diminution of the number of lines of force passing through it.

Let us consider a single linear circuit in which the current is i, or say dq/dt, then the energy

$$=\tfrac{1}{2}\int\frac{dq}{dt}\left\{F\frac{dx}{ds}+G\frac{dy}{ds}+H\frac{dz}{ds}\right\}ds,$$

where ds is an element of circuit; but by Lagrange's equation the force tending to increase q, *i.e.* the electromotive force in the circuit,

$$=-\frac{d}{dt}\int\left(F\frac{dx}{ds}+G\frac{dy}{ds}+H\frac{dz}{ds}\right)ds\,;$$

so that

$$\int\left(F\frac{dx}{ds}+G\frac{dy}{ds}+H\frac{dz}{ds}\right)ds$$

equals the number of lines of force passing through the circuit; but if dS be an element of surface closing up the circuit, l, m, n the direction cosines of the normal, then by Stokes' theorem

$$\int\left(F\frac{dx}{ds}+G\frac{dy}{ds}+H\frac{dz}{ds}\right)ds$$

$$\iint\left\{l\left(\frac{dH}{dy}-\frac{dG}{dz}\right)+m\left(\frac{dF}{dz}-\frac{dH}{dx}\right)+n\left(\frac{dG}{dx}-\frac{dF}{dy}\right)\right\}dS\,;$$

but the number of lines of force passing through the circuit

$$=\iint(la+mb+nc)dS,$$

where a, b, c are the components of magnetic induction, so that

$$a=\frac{dH}{dy}-\frac{dG}{dz},\qquad b=\frac{dF}{dz}-\frac{dH}{dx},\qquad c=\frac{dG}{dx}-\frac{dF}{dy}.$$

To connect a, b, c with the current, Maxwell makes use of the principle that the line integral of the magnetic force taken round any closed curve equals the current flowing through the curve. This leads to the equations—

$$4\pi u=\frac{d\gamma}{dy}-\frac{d\beta}{dz},\qquad 4\pi v=\frac{d\alpha}{dz}-\frac{d\gamma}{dx},\qquad 4\pi w=\frac{d\beta}{dx}-\frac{d\alpha}{dy}.$$

so that if μ be the coefficient of magnetic permeability,

$$4\pi\mu u=\frac{dc}{dy}-\frac{db}{dz},$$

and so on. Substituting the vales of a, b, c, given above, we find

$$4\pi\mu u=\frac{d}{dx}\left\{\frac{dF}{dx}+\frac{dG}{dy}+\frac{dH}{dz}\right\}-\nabla^2F,$$

with similar equations for G and H.

Now, Von Helmholtz, in his paper "Ueber die Bewegungsgleichungen der Elektricität für ruhende leitende Körper" (*Crelle*, LXXII. p. 57; *Gesammelte Werke*, II. p. 545), has investigated the most general expressions for F, G, H, consistent with the force between two closed circuits agreeing with that indicated by Ampère's theory, and he finds that if the circuits are closed circuits, as Maxwell assumes all circuits to be, then

$$\frac{dF}{dx}+\frac{dG}{dy}+\frac{dH}{dz}=0,$$

and therefore

$$4\pi\mu u=-\nabla^2F,$$

with similar equations for G and H. These equations are sufficient to determine the quantities F, G, H.

Maxwell does not at once put $dF/dx+dG/dy+dH/dz=0$; he writes J for this quantity, and puts

$$\chi=\iiint\frac{J}{r}dx\,dy\,dz.$$

Then

$$F=\iiint\frac{\mu u}{r}dx\,dy\,dz+\frac{d\chi}{dx};$$

as, however, he subsequently puts $J=0$, we may at once simplify the equation by making this assumption.

Since the kinetic energy equals

$$\tfrac{1}{2}\iiint(Fu+Gv+Hw)dx\,dy\,dz,$$

we see by Lagrange's equations that the electromotive force tending to increase u

$$=-\frac{dF}{dt};$$

in addition to this there is the force arising from the electrostatic potential ϕ, so that the total electromotive force parallel to the axis of x

$$=-\frac{dF}{dt}-\frac{d\phi}{dx},$$

so that if σ be the specific resistance of the substance, K its specific inductive capacity, then

$$\sigma p=\frac{4\pi}{K}f=-\frac{dF}{dt}-\frac{d\phi}{dx};$$

but

$$u=p+\frac{df}{dt}=-\frac{1}{\sigma}\left\{\frac{dF}{dt}+\frac{d\phi}{dx}\right\}-\frac{K}{4\pi}\left\{\frac{d^2F}{dt^2}+\frac{d^2\phi}{dx\,dt}\right\};$$

but we saw before that

$$4\pi\mu u=-\nabla^2F.$$

(To be continued.)

DELANY'S SYSTEM OF SYNCHRONOUS MULTIPLEX TELEGRAPHY.

The following description, admirable for its clearness and brevity, has recently been issued by the English Postal Telegraph Department for the guidance of its officers in fixing and working the Delany Telegraph:—

1. Delany's system is based upon two main principles, first, that of synchronism, or the simultaneous motion of similar pieces of apparatus at two different places; and secondly, that of distributing to several telegraphists the use of a wire for very short equal periods of time, so that practically each telegraphist has the line to himself during these periods. The combination of these principles of working was introduced by Meyer in 1873; it was improved upon by Baudot in 1881; synchronism was perfected by Delany in 1882, and the system completed in 1884.

2. As Delany's system differs very markedly from what are known as the duplex and quadruplex systems, it is proposed for clearer

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definition to give to the modes of working his system names based on the Greek word *hodos*, a way. Thus a two way mode of working, or a mode by which two messages are practically sent at the same time, will be *diode* working, three way *triode*, four way *tetrode*, five way *penthode*, and six way *hexode*. Duplex and quadruplex are such well rooted and explicit terms, defining particular modes of working by compensation, that their application to different modes of working based on a different idea may lead to confusion, while new and distinct terms will confine the attention to the new and distinct system.

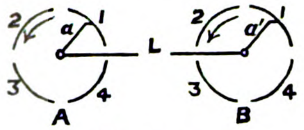

Fig. 1.

3. A and B are two separate offices connected together by a line wire, L. If the arms *a* and *a'*, in electrical connection with line wire L at A and B, rotate simultaneously around the circles 1, 2, 3, 4, in the direction of the arrows, making contact upon the segments as they pass, then when *a* is at A 1 *a'* will be at B 1, when *a* is at A 2 *a'* will be at B 2, and similarly for 3 and 4. If 1, 2, and 3, and 4 at each office be each in connection with a set of similar telegraphic apparatus the four sets at one office will be in direct communication with the four sets at the other office as the arms *a a'* touch their corresponding segments. Thus for each rotation of the arms the instruments at A 1 and B 1 will be in direct communication with each other *once*; and so on with those at A 2 and B 2, &c.

4. If each segment be divided into four segments, and by means of these be connected with the four instruments, instead

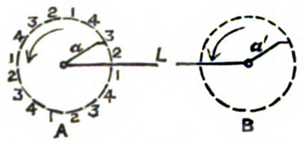

Fig. 2.

of with only one of them, then during one complete rotation each arm will place corresponding instruments in communication with each other *four* times; or, if each circle be divided into 40 segments and each of these 40 into four segments, then corresponding instruments will be in communication with each other *forty* times during each complete rotation of the arms "*a*" and "*a'*." In Delany's apparatus there are 84 segments in the whole circle, and these are grouped differently according to the number of ways of working. Hexode working requires one grouping, triode another, diode another, and so on.

5. Two tuning forks pitched to absolutely the same note, and set in vibration by currents like an electric trembling bell move in synchronism, but the synchronism cannot be maintained. The deposition of dirt, dust, or moisture, changes of temperature, variation of current, produces changes which affect the rate of motion. Paul la Cour, of Copenhagen, invented an ingenious way to

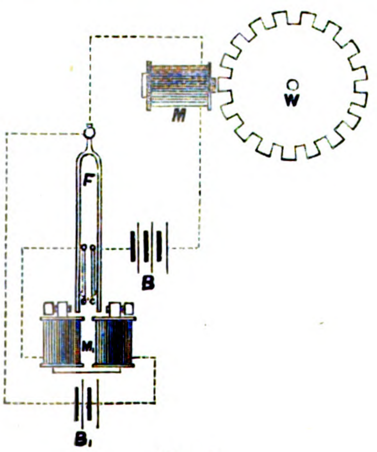

Fig. 3.

maintain the synchronism. F is a tuning fork vibrating between the poles of magnet M_1. There are two contact points *c c'*. At *c* is completed a circuit containing the battery B, and an electro-magnet M. The other contact *c'* completes the circuit containing the battery B_1 and the electro-magnet M_1. Every time the tuning fork touches the contact point "*c*" a current is sent through the electro-magnet M, which, therefore, is magnetised once for every excursion to and fro of the fork. In front of the magnet M there is a wheel, W, whose teeth are of iron, and every time the magnet M is excited attraction is momentarily exerted on the nearest tooth. If the tooth is approaching the pole it is urged forward, if it is moving away from the pole it is retarded. Hence the wheel is propelled with wonderful uniformity, and with considerable force. The electro-magnet M_1 is similarly excited, and it maintains the fork in constant vibration. This "phonic wheel," as it is called, Delany uses in connection with a "distributor"; but he has adopted a reed instead of a tuning fork.

6. The "distributor," as arranged for hexode working, is shown by—

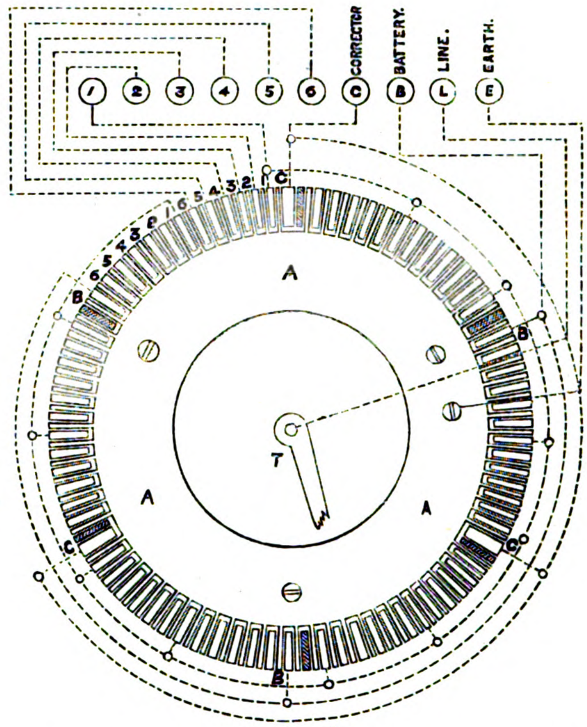

Fig. 4.

The circle is divided into six groups, each group having 12 platina faced brass segments insulated from each other, and being separated from the next group by what are called the two correcting segments, one (shaded) called "dead," and the other (clear and marked B or C) called "live." The segments are not only insulated from each other but are separated by the spokes of the brass rim A, which is connected with earth. Each group of 12 segments is further subdivided into two sub-groups of six, in which the corresponding segments are connected, so that 1 and 1, 2 and 2, 3 and 3, and so on are electrically joined together. Not only so, but they are connected to every corresponding number in the other groups around the circle. In Fig. 4 the segments in only two of the sub-groups are numbered, but the remaining 10 sub-groups must be understood to be all numbered in the same way. The twelve segments numbered 1, are electrically connected to the telegraphic instrument numbered 1; the twelve segments numbered 2 are connected to the instrument numbered 2, and so on. The first, third, and fifth "live" segments are connected together, as also are the second, fourth, and sixth, but the first three are intended to *receive* currents from the distant station, while the second three are connected to a battery B, and so can *send* currents to the distant station. The "dead" segments are so arranged that one is fixed *before* each receiving "live" segment, and one after each sending "live" segment. The correcting segments are connected in the manner described for lines whose inductive capacity is small, and where the retardative effect on the current is consequently slight; but when the capacity is considerable, the segments which are called "dead" are brought into use; the sending correcting battery is then connected to the "dead" segments immediately in front of the broad segments, and the receiving correcting relay is connected to the "dead" segments immediately following the segments shown in the figure as "live" B segments. This arrangement gives a space of one segment to allow for retardation of the current when the capacity of the line exceeds three microfarads. When, however, the capacity is within that amount this space is not required; indeed, it would be disadvantageous, because there is very slight loss of time in the transmission of the signal. The receiving correcting segment is therefore extended in such a manner as to meet the trailer, and so receive the correction almost as soon as it is sent. It is not really necessary that the segment should be made broad, but only that it should be moved in the direction indicated; it is only made broad to fill up the space.

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The arm or trailer T passes lightly on the surface, and moves continuously round the circle, coming successively in contact with every segment. It moves in the opposite direction to that of the hands of a watch. It is electrically connected to the line wire L. In every rotation it makes 84 electrical contacts, 72 of which are for telegraphing, while the others are for maintaining synchronism. The function of the trailer is to place the line wire successively in connection with the segments in the different groups. The currents of electricity that flow through the line wire are dependent upon the operations performed upon the telegraphic apparatus, and they are broken up into short rapid pulsations or impulses by the momentary contacts made by the trailer. The uniform rotation of the trailer is produced by La Cour's wheel, shown in Fig. 3.

7. Fig. 5 shows the La Cour wheel in connection with Delany's actuating, correcting, and synchronising devices. The iron-toothed wheel A is placed before the poles of the electro-magnet D, which is magnetised periodically and regularly by currents from the battery B'_2 sent at each vibration of the reed E' at H'. It propels with great uniformity the toothed wheel, to the axle of which is attached the trailer T. The impulse must be given when the tooth is at c and cease when it is at c' (Fig. 6). Momentum takes it on until the next tooth comes to c, when the next impulse is given. The impulse must last while the tooth moves from c to c'. If it continued beyond that time it would check the motion of the tooth. As the impulses are due to the vibrations of the reed the motion of the wheel must follow exactly the vibrations of the reed. Resistances

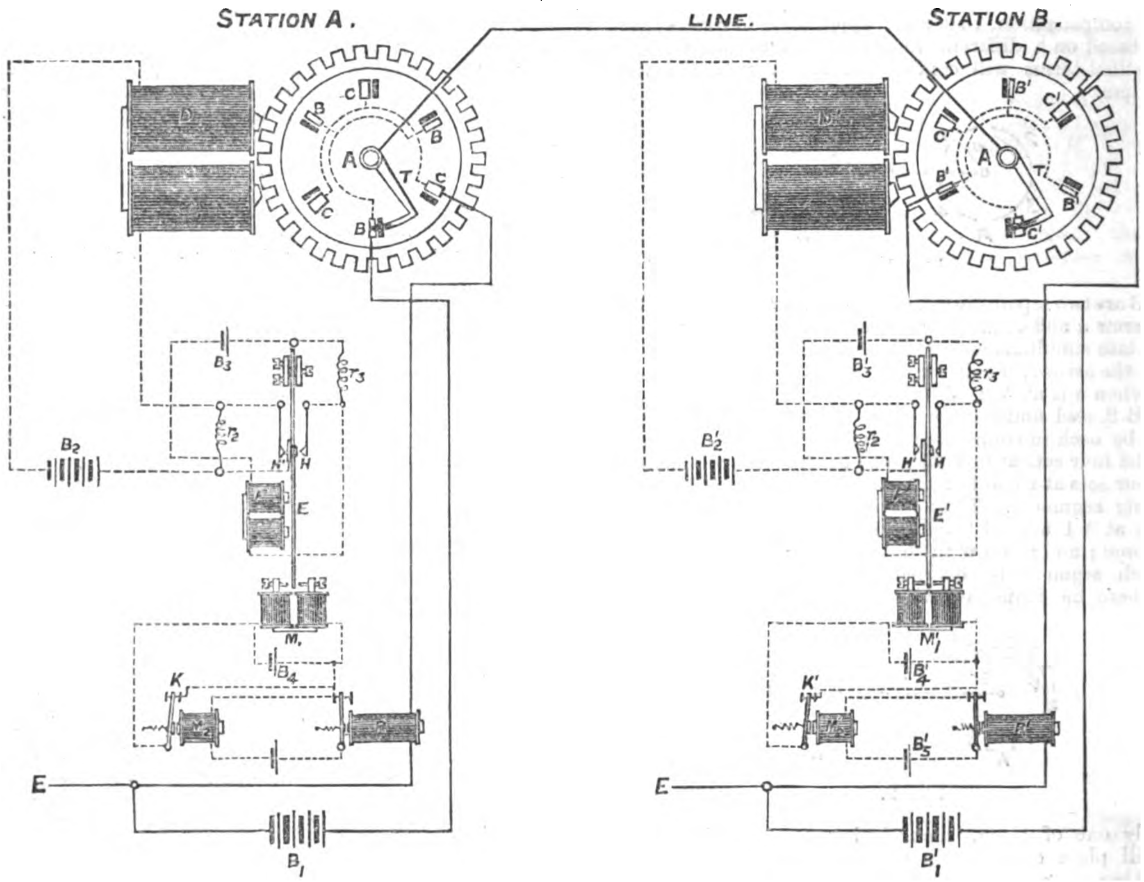

FIG. 5.

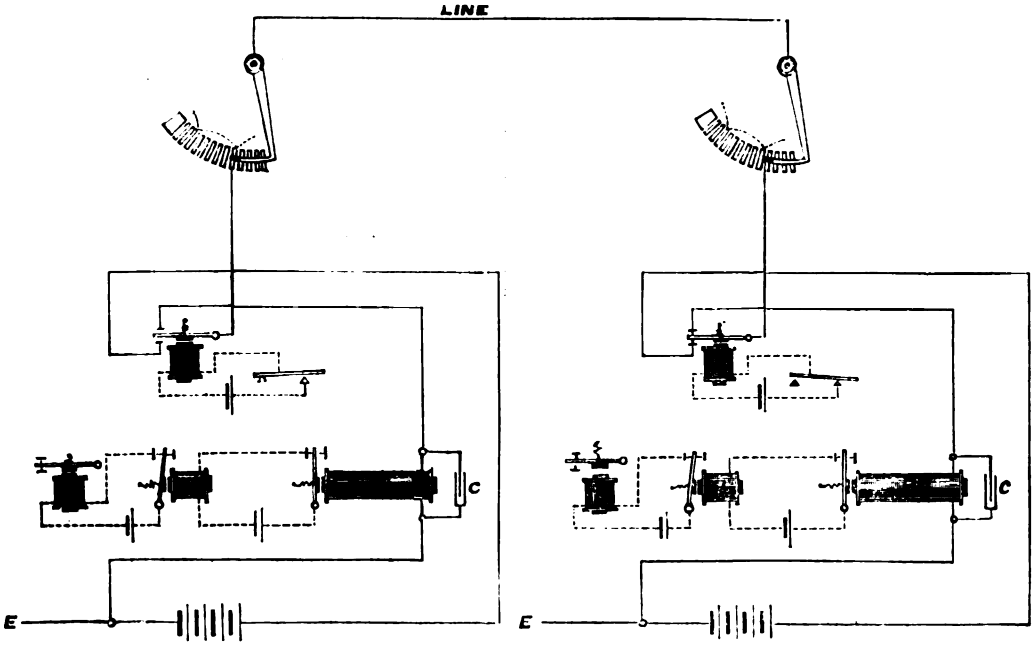

FIG. 7.

r_2 and r_3 (Fig. 5) are placed as shunts around each of the contacts H and H′ to prevent sparking. The vibrations of the reed are maintained by the electro-magnet F′ excited by the battery B'_3 every time contact is made at H. The end of the reed E′ vibrates between the extended pole pieces of the electro-magnet M'_1, and thus it vibrates in a magnetic field. This magnet is excited by the battery B'_4 whenever contact is broken at K′, and this contact at K′ is broken whenever the current from battery B'_5 ceases to flow in M'_2. This depends on the action of the relay R′, which is excited by currents received from the distant station coming through the "live" correcting segments of the "distributor" there, and which, therefore, when its armature is attracted breaks the local current flowing through M'_2. When the magnet M'_1 is excited, the magnetic field in which the iron reed vibrates tends to retard its rate of vibration by attraction, so that if it vibrates too frequently its rate is checked. The normal rate of vibration may be adjusted by a sliding weight, or in various other ways not shown in the figure. The mode in which each set of apparatus is connected up is shown by Fig. 7. A portion of one group of segments of the "distributor" at each station is indicated, and the trailers are shown to be in contact with corresponding segments which direct the current to the telegraphic apparatus. There is nothing peculiar in the telegraphic apparatus (the usual Morse sounder set), except the relay R, which by its form is rendered sluggish, so that the sharp, rapid currents collected by the trailer are practically made continuous in their action on the armature of the relay. The currents flowing through the line wire are short, sharp, rapid impulses or waves of electricity, and to convert these waves into telegraphic symbols, such as Morse characters, some mode is needed to render them continuous for the duration of a dot or a dash. The relay has a condenser C (Fig. 8), and permanent horseshoe magnet NS fixed below the coils. The cores are thus polarised.

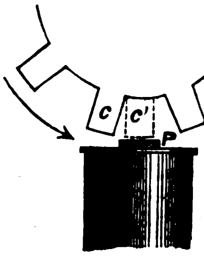

Fig. 6.

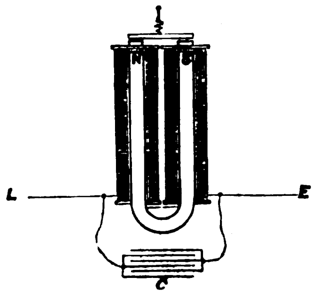

Fig. 8.

The result is that the self-induction of the coils, adjusted by the condenser, retards the demagnetisation of the core, so that the effect of the rapid succession of short currents is made continuous upon the armature of the relay, and the marks are made as though they were produced by continuous currents. Dots and dashes are thus recorded without breaks. The relay R (Fig. 7) actuates an uprighting relay, M, which in turn actuates the sounder S. This arrangement is introduced because the ordinary method of completing the local circuit is too slow and the contacts are not firm enough. It has been mentioned that each segment is separated by an earth contact—a spoke of the brass rim. This is done to favour the rapid discharge of the static charge to earth between each electrical impulse or current. The apparatus being ready, six pairs of corresponding telegraphists are placed in communication and each pair has virtually a circuit to itself.

It will be observed that in Fig. 5 only the correcting "live" and "dead" segments are shown. Of the "live" segments, those in connection with the battery are of the usual dimensions, while those in connection with the reed correcting apparatus are broad. This is to admit of corrections being made *before* the working segments are affected. Want of synchronism is thus prevented. When the trailer at station A is on the narrow segment, that at station B is on or near the broad segment. If the wheels are in perfect synchronism, the trailer at B is on the "dead" segment; when at A it is on the sending "live" one, and *vice versâ*; hence no current flows; but when the wheel at B is in the least degree in advance of that at A, then the trailer at B is on the receiving "live" segment, a current flows, it excites relay R′, the electro-magnet M'_2 is also excited, the magnetic field is formed, and the vibration of the reed E′ is retarded. Perfect synchronism is again obtained, and the correcting currents cease to flow. Six correcting currents can be sent at each revolution, three in one direction and three in the other. Thus a deviation of a thousanth of an inch can be speedily rectified.

This method of Mr. Delany's is perfectly automatic in its action, and it maintains synchronism to an extent that has never before been known. Attempts have been made to synchronise by sending correcting currents in one direction and applying the corrections mechanically to moving parts. Baudot brings to bear a friction break by such means, but it has not been successful in practice, whereas Delany's method is practical and successful. The "distributor" rotates nearly three times in one second, hence 252 contacts are made each second in hexode working. The distance to which the system can be worked hexode is limited, for owing to the retarding effect of static induction the number of currents which can be sent per second is limited by the static capacity of the line. Now, as the static capacity of the line has the effect of retarding the speed of the current, it follows that the limit of working is dependent on the magnitude of the static capacity, for if the current be late it will enter the wrong segments, and confusion of signals will result. The retarding effect of static capacity can be met by making each group of a greater number of segments, or by making the segments of greater breadth; but this has the effect of reducing the number of ways of working. Either plan would reduce the hexode to tetrode or triode working.

So far, it should be understood, the system has been described as one for working in either direction (not simultaneously as in duplex, but alternately), as in ordinary simplex working. If, however, it be regarded as a system for working in one direction, distance has not the same effect upon it. If static capacity only so reduces the speed of the current that while it leaves segments 1 at station A it enters segments 2 at station B then it is possible still to work five ways *in one direction*, for every other segment will be advanced one. For this mode of working two wires are necessary, one for sending and the other for receiving, but it has this advantage that two wires can be converted into ten circuits. Segment 6 is rendered useless in consequence of its currents arriving at B when the trailer is on the correcting segments. Working in either direction, hexode is feasible between London and Brighton, but tetrode is the limit to Bristol and Manchester. In one directon, however, to Bristol and Manchester, even six circuits have been operated, so that with two wires 12 circuits might be worked, six in each direction.

The great advantage of the system is that it does not disturb the general mode of working adopted in this country. The sounder system is retained. Key working is maintained All initial delay due to punching is avoided. The skill of able telegraphists is fully utilised. Each telegraphist has an independent circuit, so that he has not to wait for a lagging co-operator, as in quadruplex. When there is a rush of traffic in one direction the system can be worked all in one direction, and not only half of it as in the quadruplex. The system, moreover, is only in its infancy, and there is little doubt that further experience will lead to its being improved.

PROF. FORBES' CANTOR LECTURES.

(Continued from page 481.)

LECTURE II.

In the course of my last lecture I showed you the generation of electrification, and the electric forces which were thereby produced; I explained to you what we meant by saying that two things have a difference of electrical potential, and I also demonstrated to you the condition that exists when two bodies have a difference of electrical potential—that is to say, that there is then created an electromotive force, and if that electromotive force is capable of acting through a conductor, you saw that there is a momentary current and a rearrangement of the electrification. If, however, the electromotive force is acting upon an insulator, no current can pass. There is simply a state of strain created in the insulating medium, which is ready to produce the phenomena of induction as soon as the facility is offered to the apparatus. We are accustomed to measure that difference of potential in terms of some unit, and the unit that has generally been adopted is called a volt, and when I say that there is a difference of potential in the machine I am using, between the two knobs of the machine, amounting to 50,000 units, I mean that that would be 50,000 volts. That is about the difference of potential which we are in the habit of employing when we are using these electrical machines. If I rub a piece of sealing-wax with flannel I get a difference of potential amounting to an enormous quantity like that, and yet I can get no serious injury from it, because the quantity of electricity is so small. We shall be going on to-day to show the means which we have for generating electricity in much larger quantities than we can by means of the appliances which were at our disposal in the last lecture. When we come to speak of batteries and the other means for generating electricity in quantity we shall be using very much smaller differences of potential than what we used in the course of the last lecture. A single battery may have one or two volts difference of potential, but the difference of potential that exists in the battery is exactly of the same nature as that which exists in the Wimshurst machine which you saw on the last occasion. The electric current which passes to the earth during a lightning flash is identically the same in character as the electric current which passes through our telegraph instruments, or which is lighting up this room at the present moment by means of these glow lamps round about. It is hardly necessary at present to insist upon it that there is only one kind of electric current. In former days it required the researches of the ablest experimenters to prove to the scientific world that the electric current generated by means of our Wimshurst machine was the same in

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character as the electric current which can be generated by means plates of metal in an acid. But we know with certainty that the effects are the same. I shall simply attempt to show you one experiment with the Wimshurst machine to prove to you that one of the effects which we shall frequently find in dealing with batteries can also be produced by means of such an influence machine. I have here a small piece of tin foil, which I shall place between two pieces of glass, and I shall then subject the two ends of the tin foil to the influence of an electromotive force due to the difference of potential between these two poles—these two knobs. Then when I discharge this machine, which enables us to get a considerable quantity by means of the Leyden jars attached to it, we shall be able to pass the current through this piece of tin foil and show the heating effect which is thereby produced. This is a neat illustration of the analagous effects which may be produced by means of this influence machine and the totally different means of generating electricity which we have in batteries or dynamo machines. [Experiment.] The spark has now passed between the poles, and I will just hand round one of the tin foils that were put there originally and another showing the fused condition of the tin foil immediately afterwards. The effect is even more powerfully shown in this case, which I shall leave on the table, where not only has the tin foil been actually fused, but the glass has been pierced and shattered by the power of the discharge. [The various objects were handed round for inspection.] The quantity of electricity which is developed in the course of these powerful discharges is very small indeed. In fact, Faraday stated that in the most powerful lightning flash there is not so much electricity passing as there is at the time when we decompose by an electric current a single drop of water—the quantity is so very feeble. But there are many ways in which we can conceive of an electric current passing when bodies are charged in this way. For instance, if a conductor were to be moved backwards and forwards between these two poles there would be a steady conveyance of positive from one side to the other, and of negative electricity in the opposite direction, which is identical in character with an electric current. Many years ago Prof. Rolland, working in Berlin, saw that an electric current could be produced in another way. Simply by charging a body with electricity and moving it with great rapidity, he was able to produce effects analogous to those which are to be seen by the use of a current generated from a battery—such effects as we shall presently be observing. Then Prof. Rolland accordingly proved by experiment that the carrying of a charged body through space is equivalent in its action to an electric current such as we shall be dealing with to-day. I will now show you some simpler methods we have for creating an electric current, and I will begin by throwing upon the screen a cell containing dilute sulphuric acid. Having thrown upon the screen this cell, I will in the first place introduce into the cell a wire of copper; and you see that the wire there is in perfect focus, with nothing else near it. I will now introduce a piece of pure zinc, and there is not the formation of gas or anything appearing there. I will now introduce the two simultaneously—the zinc and the copper—and still there is no appearance of any gas whatever in that arrangement; but so soon as I touch the two metals we shall see that there is an evolution of gas. Gas now is seen to be given off from the thin one, which is the copper. That gas is hydrogen gas, and it shows that the condition of the cell is something different from what it was before. As a matter of fact there is an electric current passing through these metals. Instead of connecting them in the liquid it is sufficient to connect them outside the liquid, and now the gas is still seen to be given off from the copper. The hydrogen is seen rising in small bubbles. [Experiment.] I will now, instead of connecting them as I have done at present, which is an outside connection, connect them metallically by a good conductor, and make the metal connection by a long wire which passes to this apparatus here and round the coil which you see facing you in the instrument there. [Indicated]. Inside this coil I have a magnet, to which the vertical index is attached. We shall see that when the current which we have spoken of is circulating through the wire in this coil there is a deflection of the magnet, and that these will serve as an indicator to us in the rest of our experiments to show when we have got a current or not. I now replace the zinc in the solution, and you see the bubbles being given off, and also the index marking that there is a current passing. [Shown.] I now remove this, and you will see that the index, after a few vibrations, will return to rest. [Shown.] Now, in making a coil for this purpose it is necessary, in order that the current may pass through all the different convolutions of the coil, to separate them from each other by an insulating material. If this were not done the current would take a short cut, and would not act in the manner we desire. To guard against this, my coil here is covered with silk thread, silk being an insulator, but that silk is not so thick as to prevent the difference of potential from passing across from one wire to the other if that difference were very great. If I were using a high difference of potential it would be necessary to use some thicker insulation than that. That is a point which has to be attended to in constructing powerful dynamo machines, and so on. We shall be using this apparatus as a galvanometer for measuring the current on several occasions. But we have another apparatus which is very often used by investigators, and which the philosopher finds peculiarly suitable for some very delicate measurements. That instrument is the ordinary Bell telephone, which consists of a magnet having a coil of wire wound round its end. The pole of the magnet is placed close to a disc of thin iron. Now, when a current which varies either in strength or in direction is passed through the coil, the attraction between the magnet and the disc is subject to similar variation. The consequence is that the disc gives off vibrations to the air, and an audible sound is heard, and as this instrument has become of great use—one which Prof. Hughes has largely used in his celebrated researches—I think it worth while to direct your attention to it. I will connect it with the battery, and take one end of the wire along the terminal of the battery so as to make and break contact very rapidly, and the telephone will give out a noise which will probably be audible to every person in the room. [Experiment.] That noise is coming from the telephone. The telephone is able to make the current audible through the whole room. You may imagine what a very feeble current may be audible when the experimenter himself places the telephone close to his ear. This, then, proves to us some of the effects which are produced by an electric current. An electric current is simply the result of our having an arrangement which enables us to keep up a constant electromotive force. In the case of influence machines, which I have been using so frequently, I am not able to maintain that high difference of potential constantly. If the two knobs are connected with a conductor, so soon as the contact is made with the conductor the whole of that quantity of electricity spreads through the conductor, and neutralises the whole effect. It is only by having a copious quantity generated or maintained by the chemical action that is going on in this cell that we are able to get a constant flow of electricity through the wire. The difference of potential created in this cell is exactly of the same nature as the difference of potential which we have between the poles of that machine. Now, I should like to bring to your minds a little more clearly the bearing of these experiments upon the production of energy in the cell, and which I have spoken of as the electromotive force of the cell. I have been using in this little cell a piece of copper and zinc in dilute sulphuric acid, and the electromotive force of that arrangement is perfectly definite. It does not depend in any manner upon the size of the apparatus. I have here a large cell containing large sheets of copper and zinc, and the electromotive force which is created in this cell is not one particle greater than that created in the other cell, and I can show this to you in a very convincing manner. I will connect this little cell with that very large cell in two different ways. I may connect the zinc of the one with the copper of the other, in which case I get a double effect. I get the sum of these two electromotive forces working throughout the metallic circuit. Or I may connect the zinc of this cell by a wire with the zinc of the larger cell, so that the two electromotive forces are acting in contrary directions. We shall then be able to see whether the electromotive force of the one is equal to the other, because the galvanometer will indicate to us the effect produced, which is due to difference in electromotive force, whatever it may be, between the two cells in which we are experimenting. Now, I have all the connections perfectly correct, so that the zinc of the little cell which I have been using hitherto is connected directly with the zinc of this large cell. The copper has a wire passing through the galvanometer and back to this large cell. Now, will you kindly watch the galvanometer while I introduce the zinc into this small cell, and so complete the circuit, and the deflection will be a very small one indeed. [Shown.] The needle is standing actually at zero. Now, I have two batteries in the circuit of zinc and copper, each of them capable of giving the deflection you saw, but they are so connected that they tend to deflect the needle in opposite directions. And as the needle remains at rest this shows that they are exactly equal in their effect. It will be well now to say a little about some of the different kinds of battery which are used. This arrangement does very well for a short time, but the trouble is with the gas which you saw upon the screen being deposited upon the copper. That hydrogen gas has an injurious effect, and tries always to set up a current in the opposite direction to that which we wish to utilise. Various means have been proposed to get rid of this hydrogen, and the first arrangement which was completely satisfactory was what was known as the constant cell of Daniell. Here I have a double cell of Daniell's construction, and here I have a slightly different cell—which you can examine afterwards—of Daniell's construction, which is not charged. Daniell's cell consists of plates of copper and zinc. I have two cells here, and the zinc of the one is attached to the copper of the other. The copper does not dip into the same vessel as the zinc, but is put into an interior vessel of porous material, through which the liquid can soak, and this vessel is filled with crystals of sulphate of copper—such as I have in my hand [shown]—dissolved in water, and the outer vessel in which the zinc is contains the sulphuric acid. In this case hydrogen is generated exactly as it was generated in the experiment upon the screen, but with this difference, that the hydrogen never reaches the copper, because the solution of sulphate of copper has this action, that it gives off the copper from its molecules, and takes in the hydrogen instead, and thus the solution is decomposed, part of it being converted into sulphuric acid by uniting with the hydrogen, and thus bubbles of hydrogen are never allowed to accumulate on the copper plate. In the centre of the table there is a large battery of Daniell's cells, which can be examined afterwards, and where you will see the arrangement of them when they are put in series, so as to increase the electromotive force. In that battery there are five of these cells, and therefore we have five times the electromotive force, and five times the power of overcoming resistance. Further along we have five Leclanché's cells, such as are used in the Post Office. Here I have a battery of totally different construction. This is not dependent upon chemical action, but is dependent on the conversion of heat directly into electricity. This pile which you see before you consists of a series of pairs of two different metals; one is iron, and the other is a compound of zinc and antimony. Each pair is joined together at the outside of this pile, and they are then joined so as to make a continuous series joined at their centres, so that the different pairs are joined in series right round the pile, and from the top to the bottom, making in all something like 75 pairs coupled altogether in series so as to multiply the electromotive force of a single pair by 75. This is connected with the galvanometer, and you see that when I make contact there is no current passing whatever, the reason being that the temperature of the inside and outside

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junctions of this apparatus is the same. But now I will take a light and heat up the interior by means of a burner which is now acting, and you will gradually see the formation of the current—it takes some five or ten minutes to acquire its maximum effect. [Experiment.] Now you see the effect of current which is being sent through the galvanometer. In a battery we have two things to consider, not only the electromotive force which is capable of generating the electricity, but also the resistance of the battery. When we have our complete circuit, consisting of any one of these batteries, to generate the electricity, wires going to the apparatus to carry the electricity, and an apparatus in which the electricity is to be used, we have two things to consider. We have a certain amount of electromotive force in this circuit, and we have a certain amount of resistance in this circuit, the greater the electromotive force the greater will be the current we get, and the lower the resistance in the circuit the greater will be the current which we get. Consequently, in order to get the best effect we generally wish to have a battery of very low resistance and very high electromotive force, but we also wish to have a small resistance in our wires which go to the apparatus on which we are using the electricity, and we also want a small apparatus where the electricity is being used. At the present moment I have got a zinc plate fully immersed, and a copper plate only just dipping into the liquid and the needle, and you see that we have a deflection of about 45 degrees or thereabouts. I can vary the conditions of the problem by varying the resistance of the battery. Leaving the resistance of this galvanometer the same—leaving the wires identical—I can lower the copper plate into the liquid, and thus diminish the resistance of the battery, and as I do so the deflection immediately increases. [Experiment.] Now the needle is permanently deflected quite to the end of the scale, and it resists intensely any effort to cause it to rise, showing this—that the current is stronger when the resistance of the battery is diminished. In the same way it may be shown that, if I brought the plates nearer together, the resistance would be less, and consequently we get a greater deflection; for, having a larger surface of plate, or having the plates nearer together, tends to diminish the resistance. Now, what happens during the time that the current is passing? I am not going to ask you to go into the theoretical views of any persons on electricity in this connection. We know that there is a certain stress in a medium when electrified bodies are fixed in equilibrium, and we know that there is a change in this condition of stress when the equilibrium is destroyed. But I am not going into what kind of change that is, and what is the medium under these circumstances. I wish to ask what becomes of this energy which is being created when it has overcome a resistance in the outer circuit? The answer to that in the first place is that the energy cannot be destroyed, and in accordance with the principle of the conservation of energy we must be able to find out what it is converted into, and we find by experiment that the energy when passing through a resistance is converted into heat. This is a transformation of one kind of energy into the other, which transformations lead to notions of the correlation of physical forces, and the conservation of energy, of which there are so many illustrations in physical science. It will take but a few moments to show the transformation of one kind of energy, heat, into the other kind of energy, electricity. Now we are speaking of the changing of electrical energy into the energy of heat. I will show you many illustrations of this principle. I could not show you a better one than the means of illumination which we have in this room now. In every one of these glow lamps we have a brilliant illustration of the conversion of electrical energy into heat. The heat in each of these glow lamps is very large, and the whole electrical energy consumed in these lamps is shown to us by the brilliant light and consequent radiation of heat which takes place from these lamps. I will make use of these very glow lamps to illustrate some of the other points in connection with resistance. I will connect one of these lamps with a battery containing a certain number of cells. Fifty-five cells are upstairs, and are connected by a wire with the wire I hold in my hand. I now make the contact here, and immediately the glow lamp, which is connected and in the circuit, gives off a certain amount of heat, and that brilliant glow is an indication to you of the strength of the current [shown] when the resistance of a single glow lamp is in the circuit. I now change the connection, and put two of these lamps in series, so that I have nearly doubled the resistance of the circuit, and you will see that the current is by no means so strong, as is shown by the fact that the lamp only acquires a dull red heat. [Experiment]. I might show you numerous illustrations in confirmation of the fact that when we increase the resistance we diminish the current, and when we diminish the resistance we increase the current. Here I have a platinum wire stretched, through which I shall pass an electric current so as to render it incandescent. Part of this platinum wire is straight, and a small portion of it is coiled up into a loop. I will place a spirit lamp under the coil part. By heating this coil part by the spirit lamp I increase the resistance of that portion because the resistance of the wire increases with the temperature, and what I want you to see is that when I increase the resistance of that platinum wire by bringing the spirit lamp under it the current is diminished, and therefore also the intensity of the glow in the other part of the wire. [Experiment.] Consequently, I shall begin by showing you the converse of the experiment. I will cool that glowing coil, and thereby diminish the resistance, and the increase of current which ought then to flow through the wire will probably be susceptible to you by an increased glow in the straight portion of the platinum wire. [Experiment.] I wish you not to concentrate your attention upon this bright glow, but upon the straight portion of the wire, which is glowing comparatively feebly. I will put the ice on to this part of the coil, and see whether we are able to get an increase in the straight portion of the wire. [Shown.] Distinctly, there is an increase. I will now try to get the effect of heating it still more by aid of the spirit lamp. [Experiment.] There is a decided diminution in the brilliancy of the straight portion of the wire, showing that the current has been diminished by the heat of that wire. I have shown you now how a current may be increased or diminished by the resistance which is in the battery, or which is in the conducting wire. I should like to show you a similar effect with the galvanometer. This leads me to say a few words about the choice of the galvanometer for delicate experiments. The greater number of turns I have round my galvanometer, the greater number of times is the needle influenced by the galvanometer. Each turn exerts its influence. Therefore, you may expect the greater the number of turns you have round the galvanometer, the greater will be the influence upon the needle. But, on the other hand, when we increase the number of turns round the galvanometer we increase the resistance, and when we increase the resistance too much, we may diminish the effect in the galvanometer. It is often remarked that for certain kinds of work, such as Atlantic telegraphy, we require high-resistance galvanometers. The student is sometimes perplexed and led to think that the virtue of a high resistance galvanometer is in its resistance. It would be, perhaps, less misleading to call it a "many-coil" galvanometer. I have here a compass needle which I am able to project on the screen with a hydrogen lamp, and I will show you the effect of a coil through which a current is passing. You see the compass needle, which I will first bring over the zero line. I have a coil in its neighbourhood capable of deflecting the needle. I will connect the coil, and you will observe the deflection. [Experiment.] Observe exactly what is the position of the needle. It is at the fourth division from the zero line. At the present moment I have got 10,000 turns round the coil of my galvanometer. I will reduce the number by 2,000, and you see the deflection increases when I reduce the number. In reducing the number of turns I have also increased the resistance, and the result was that it went further away from the zero line. I will now take out another 2,000 turns, and you will see the needle go a little further in the same direction, showing an increased effect, and finally I will take out another 1,000, and there will be a slight impulse, I think, in the same direction, thus showing that we get an actual increase in the deflection when we diminish the number of turns in our galvanometer. Another very beautiful illustration of the consumption of energy by producing resistance is in the electric arc. The electric lamp, which you have seen at work in the different illustrations, is produced by two pieces of carbon connected with the poles of a powerful battery, and brought first to touch and then separated to a slight distance. This experiment was first performed by Sir Humphrey Davy. [Experiment.] Now, these are the images of the two carbons whose ends are placed opposite each other, and a great deal can be learned by a careful study of that magnificent image. In the first place I will show you that they are not touching, and yet the current is able to pass across. The only reason why it is able to pass across that sensible space of air is that the air becomes enormously heated, and when the temperature of the air is increased, as it is in this case, it becomes a fair conductor of electricity. There the carbons may be seen glowing hot. [Experiment.] They touch, you notice, and then an automatic arrangement separates them. You will notice particles of carbon continually flying off, small portions of electrified matter being continually given off. This pole, which is called the negative pole, is connected with the zinc of the battery. This, which is called the positive pole, is connected with the copper of the battery. You will notice an accumulation of impurities on the surface of the globules. I should like to be able to show you the deflection of this current, which you can see by the illumination which exists between the two poles. If Mr. Devonport would introduce a magnet there you would see the violent evolution of these particles of carbon. [Experiment.] I wish now to try and show you an experiment of another kind—not the heat that is produced by electricity but the chemical action which the heat produces. Here I have a current going to two platinum points at the bottom of this dish of water. Now I will send the current through it, and I shall be able to show you the evolution of gas. [Shown.] This is one of the most elementary of the chemical phenomena which are produced by electricity. If I were to allow that to go on we should get the tubes filled with oxygen. [He concluded this experiment at the close of the lecture.] In the meanwhile I wish to try and show you the way in which electricians actually measure the resistance of any wire or any other material which may be before them; and it is founded upon the principle that if we connect the wires with a galvanometer at two points which are of the same electrical potential, no current will pass through the galvanometer. Professor Adams has made some very pretty experiments in his laboratory in tracing out the potential lines in that way. This is one of his actual experiments. [Indicating it.] But perhaps this rough sketch in chalk brings out more forcibly the same results. He was able to trace out along these potential lines a line in which the potential was equal all over, and so succeeded in determining the difference of potential in the rest. Now, I am going to apply the same sort of thing in measuring resistance. Here is a piece of gilt paper. It is an irregular piece of paper. [Exhibiting a strip of gilt paper of varying breadth, he demonstrated by means of the galvanometer how to find the difference of potential.] Now, I wish to show you a very peculiar experiment. Here I have a highly polished steel plate. It has no mark upon it whatever. I will put it into this vessel, which I will fill with acetate of lead, and then I shall place a sheet of copper just dipping into the liquid, and finally I shall pass a current through from the bottom steel plate to the other copper plate, and the consequence will be that there will be a deposit of peroxide of lead, varying in thickness, thereby showing the beautiful colours of thin films which Sir Isaac Newton worked at, and which are caused by the varying absorption of light due to the varying thickness of the films of peroxide. [Experiments.]

(To be continued.)

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COMPANIES' MEETINGS & REPORTS.

Railway and Electric Appliances Company.

The ordinary general meeting of the shareholders of this Company was held at the Cannon-street Hotel on the 28th ult., under the presidency of Colonel R. R. Jackson.

The SECRETARY (Mr. W. Shepherd) read the notice convening the meeting.

The CHAIRMAN, in moving the adoption of the report and accounts, regretted that there had been no marked improvement in the position of the Company since their meeting last year. The loss at the Polmadie Works, together with the expenses in London, had been £3,753. Of course, in their financial position this was a heavy loss, but still it was less than that of the previous year, which amounted to £4,888. In that year, however, the loss was increased by £700 on account of depreciation, whereas for 1885 nothing had been allowed for depreciation. The loss at the works in 1884 was £1,885, against £845 last year. Although, however, the loss on the working of 1885 appeared as £3,753, that included £2,000 for directors' fees, but as the Board proposed to take only £450, the loss was practically reduced to £2,200. The Board intended to reserve control over the sum of £1,550, which they were not taking, in order, if necessary, to meet contingencies like those which arose in 1884, when the Directors really had no remuneration. There was no doubt that their working in the past year had been affected by the depression of trade—a circumstance not peculiar to their Company; and beyond that they had had to face a disappointment. He informed them at the last meeting that the Williams cross-over had been successfully applied on one railway, and that they had received a second order from the company referred to. This second installation had given satisfaction to the railway company, and they had been led to suppose that it was probable that orders would be given to them by other railway companies. In that expectation, however, they had been disappointed, and they had not received a single additional order for anything made under the patents of Mr. J. S. Williams. He thought there could be no doubt that there was merit in those inventions, but he was not surprised at the conservative spirit exhibited by railway managers. Probably they would one day entertain a higher opinion of what he himself believed was an important invention. It was satisfactory to know that there was a continued demand for the waggon fastener, for which the Company held the patent. There was also an increased demand for the compensator, which they also controlled; and they had secured licenses for the use of some inventions on payment of royalty without in any way trenching on their funds. Another favourable feature was that they had received a large order for general business from an important railway company, and they had received smaller orders from other railway companies. He therefore thought there were indications that their business in that particular direction would develop somewhat freely. He could not say that he was able to put before them a sanguine picture, but nevertheless they ought not to give up the hope of seeing the Company in a better position.

Mr. F. G. SMITH seconded the motion.

The CHAIRMAN, in answer to questions, stated that they had been engaged in a number of lawsuits, which it had been their endeavour to get rid of. The result was that they had had to pay pretty heavily for law expenses, but nothing like the amount they would have had to pay had the lawsuits continued. If, as Mr. Cumming suggested, they were to sell the Polmadie works and do only an agency business, it would be just as well to take the next step, and wind up the Company. They thought they might get the Company into a better position by continuing the works. He then read a letter from a shareholder, suggesting the appointment of a committee to investigate the position of the Company before the proposed call of 2s. 6d. a share was made. He afterwards observed that it was better to pay a small call now, with the view to resuscitate the Company, than go into liquidation, which would involve the whole of the unpaid capital, 7s. 6d. a share, being called up.

The report was then adopted, and the retiring Directors and auditor were re-elected.

An extraordinary general meeting was next held, when the following clause was added to the Articles of Association:—"Article 38A. The Directors may accept from any member, on such terms and conditions as shall be agreed, a surrender of his shares or stock, or any part thereof."

The proceedings terminated with the usual complimentary vote to the Chairman and Directors.

Submarine Cables Trust.

Report of the Trustees to the fifteenth ordinary annual meeting of the certificate holders, to be held at the Offices of the Trust, 50, Old Broad-street, E.C., on 11th inst., at three o'clock:—

The revenue for the financial year, to 15th April last, including the balance brought from the previous accounts, viz., £1,949. 16s. 8d., and including the dividend on the Eastern Extension Shares referred to in the last report of £2,987. 11s., amounted to £23,776. 5s. 6d. The expenses of the Trust for the twelve months amounted to £1,349. 14s. 10d. The payment of two half-yearly coupons at the rate of 6 per cent. per annum absorbed the sum of £20,286, leaving a balance of £2,140. 10s. 8d. to be carried forward. The decrease of revenue this year has been entirely owing to the diminished dividend paid by the Anglo-American Company, in consequence of the competition with the Commercial Cable Company. The securities held by the Trustees remain unchanged. (Particulars of the original and present investments of the Trust are given as usual in the table which accompany the report.) The meeting will have to elect two auditors for the current year; Mr. John G. Griffiths and Mr. John Gane offer themselves for re-election.

The Brazilian Submarine Telegraph Company (Limited).

Report of the Directors for the half-year ended 31st December, 1885, to be submitted to the twenty-fifth ordinary general meeting, to be held at the Cannon-street Hotel on the 12th inst., at 12 o'clock:—

The revenue for this period amounted to to £77,066. 0s. 10d., and the working expenses to £12,893. 5s. 5d. After providing £9,680 for debenture interest and sinking fund, and £1,199. 15s. 4d. for income tax, there remains a balance of £53,293. 0s. 1d.; to this is added £2,830. 16s. 3d., brought forward from 30th June last, making a total of £56,123. 16s. 4d. First and second interim dividends amounting to £39,000 have been paid, and £15,000 transferred to the reserve fund, leaving the sum of £2,123. 16s. 4d. to be carried to the next account. The message receipts for the half year amounted to £76,825, which shows a decrease of £12,178 when compared with the receipts for the corresponding period of 1884. This large decrease has been caused principally by the depressed state of trade and the decline in the rate of exchange. With respect to the latter the Directors are glad to report there is now a marked improvement in the exchange value of the milrei. All the Company's cables are in good working order. Acting under the authority given by the shareholders to the Board at the extraordinary general meeting held 21st January last, this Company has joined with the Eastern Telegraph Company and the Telegraph Construction and Maintenance Company in the formation of the African Direct Telegraph Company. That company's cable from St. Vincent to Bathurst on the African coast is already laid and will shortly be ready for traffic; the other cables are in a forward condition of manufacture, and it is expected that they will be laid and in operation during the present summer. The interest of the Brazilian Company in the telegraphic communication with the West Coast of Africa is very important. The line will be worked at St. Vincent in this Company's station, and it is agreed the telegrams between England and Africa for and from the African Direct Telegraph Company's system shall be conveyed by the cables of the Brazilian Company between St. Vincent and Lisbon, and by those of the Eastern Company between Lisbon and London.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES. MAY 5.		BUSINESS DONE WEEK ENDING MAY 5. Highest.	Lowest.
Anglo-American	81,	82	82	81
Do. Preferred	52½,	53½	53½	52½
Do. Deferred	9¾,	10¼	10⅜	9⅝
Brazilian Submarine	10⅝,	10⅞	11⅛	10¾
Cuba	10½,	10¾	10½	10⅜
Do. Preference	18,	19	—	—
Direct Spanish	1⅛,	2	—	—
Do. Preference	9½	10½	—	—
Direct United States Cable	8⅞,	9⅛	9¼	8 13-16
Eastern Telegraph	10⅝,	10⅞	11¼	10¾
Do. 6 per Cent. Preference	14⅛,	14⅜	14½	—
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	11¾,	12	12¼	11¾
German Union	9¼,	9¾	9¾	9½
Globe Telegraph and Trust	6½,	6¾	6¾	6 9-16
Do. Preference	13¼,	13½	13⅝	13¼
Great Northern	13½,	14	14	13 11-16
Indo-European	34½,	35½	35½	34⅝
Reuter's	6,	6½	6½	—
Submarine	200,	210	207½	203½
West India and Panama	¾,	1	13-16	—
Do. 1st Preference	9,	9½	9 5-16	9½
Western Brazilian	7⅛,	7⅝	—	—
Western Union 7 per Cent. 1st Mortgage	118,	122	—	—
Do. 6 per Cent. Sterling Bonds	103,	107	—	—

TELEPHONES.

Consolid. Telephone and Maintenance	⅞,	1	—	—
Oriental	3-16,	5-16	—	—
United Telephone	12⅞,	13⅛	13⅛	12 15-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 paid)	2⅞,	3⅛	—	—
Do. (fully paid)	4½,	5	4¾	—
Swan	1⅛,	1⅜	1	—
Maxim-Weston	¼,	⅜	—	—

MISCELLANEOUS.

Telegraph Construction	36½,	37½	37½	36¼
India Rubber, Gutta Percha, and Telegraph Works	23,	24	23½	23¼

TRAFFIC RECEIPTS FOR APRIL, 1886.

COMPANIES.	April, 1886.	April, 1885.	Increase.	Decrease.
Cuba Submarine	3,300	3,886	—	586
Direct Spanish Telegraph	1,597	1,510	87	—
Eastern Extension	34,292	41,233	—	6,941
Eastern Telegraph	47,611	63,085	—	15,474
Great Northern	19,800	—	—	—
West Coast of America	3,225	—	—	—

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